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REPORT

OF THE

ENTOMOLOGICAL DEPARTMENT

OF THE

New Jersey
Agricultural College Experiment Station,

BY

JOHN B. SMITH, Sc.D.,

For the Year 1897.

TRENTON, N. J.:
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With Compliments of
John B. Smith

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REPORT OF THE ENTOMOLOGIST.

Fig. 1.

REPORT OF THE ENTOMOLOGIST.

JOHN B. SMITH, SC.D.

General Review.

As compared with the years immediately preceding, the early season of 1897 was wet and cold. The result is, that quite different insects attracted attention, while some most troublesome in 1896 were absent in 1897.

A marked example is the *Army worm*, not a complaint of which was received. In collecting at sugar, the moths were rarely seen until late, and not then in abundance.

The *Hessian fly* also dropped out of sight; not an instance of injury having come to notice. The insects are still with us, ready to increase whenever circumstances become favorable, hence the precautionary measure of late planting should continue to be practiced.

The *Pear midge* has made no spread and seems to have been actually stamped out in certain localities. The infested point near New Brunswick has been cleared by uprooting most of the old trees referred to in previous reports, while the land has been thoroughly cultivated. It is too much to expect that the insect has been really exterminated; but it need cause no further alarm if the recommendations in previous reports be heeded.

The *Sinuate pear borer* has also been checked, and in some places destroyed. Near Roselle, where it was abundant three years ago, persistent weeding out of infested trees has been so effective that none were observed in 1897. It is still present around Irvington, where Clerid larvæ are doing much to lessen it—at least half the burrows examined having the predatory species instead of the borer.

The *Wood leopard moth* is holding its own; but I have no accounts of any extension into new territory. New parts of Newark and

Elizabeth have, however, reported the species, and many dead trees have been taken out. No effort has been made to check further spread.

The *Elm beetle* has been less abundant than usual, more because of the conditions in 1896, than of adverse surroundings in 1897. Few specimens hibernated in their usual quarters, and the College janitors early reported that where they had been used to sweeping up hundreds on the arrival of warm weather, they then found only isolated specimens. The beetles were late in appearing, and so few egg patches were seen that it was decided to omit spraying the College elms against the adults. Though the number of larvæ seemed disproportionately great as compared with the adults observed, it was decided to omit spraying altogether, especially as everything pointed to a wet season, in which the trees would be able to resist or repair injury. The decision was justified by the result, the trees remaining in good condition to the end. As the number of hibernating beetles was small, an unusual opportunity for choice was afforded, hence European and smooth-leafed varieties suffered much more than the thick, rough-leafed types. Some of the former were as severely injured as ever before, while the others were nearly free and practically uninjured. The larvæ pupated and changed to adults in good condition; but the new beetles did no feeding, and were driven, by stress of weather, into early winter quarters. After August 1st not an elm beetle in any stage was observed in New Brunswick, and there was not even the fragmentary second brood that has been observed for several years. These conditions apparently prevailed throughout the State, for I had few complaints, and observed no badly-injured trees anywhere.

The *Maple pseudococcus* was present in scarcely noticeable numbers. Trees plastered with it two years ago were free, and on only a few New Brunswick trees was there even a slight development. I recorded in 1896 a decided decrease in this insect, questioning whether climatic conditions were in any way responsible. This year the decrease has been even more marked, while the climatic conditions have been completely opposite. It seems another instance where an ordinarily scarce species increases beyond all precedent and then slowly drops back into its former inconspicuous condition. Yet it would not be safe to say that next season will not witness a renewal in the activity of the insect.

No complaints were received of the cottony maple scale, which last year occurred in numbers, and this is what I suggested would happen in my last report. There was a great mortality among the young scales and few breeding females were seen where they were most abundant in 1896.

The *Harlequin cabbage bug*, which promised to become troublesome, seems to have experienced a decided check from the cold, wet spring and early summer. This insect is an immigrant from the South, and would be likely to prove sensitive for a time to adverse climatic conditions in the extreme northern limit of its range. The fears expressed for 1897 were not justified, but this gives no warrant for assuming that more favorable conditions in 1898 will not give the insects a new start and a firmer hold.

April 9th, Professor H. E. Weed, of Mississippi, wrote that it made no difference at what time of the day the adults were collected from the plants; that there were still many points to be ascertained regarding life history, distribution, etc., and that even the winter quarters were not definitely known. He added: "In the spring of '91 I collected a gallon and a half of them off some mustard plants in the Horticultural Department of the college and killed them all off during early April. This year I have found 187 specimens to date—a few less than were to be found, you see, in 1891."

July 31st, Professor H. A. Morgan, of the Louisiana Station, kindly sent me a vial containing parasitized eggs of the bug and suggested that the parasites should be bred in confinement and then liberated in infested fields. The parasites hatched in due time, but unfortunately no eggs of the bugs upon which they could be further bred were obtainable. Should the insects become numerous in 1898, the introduction of this parasite will be again attempted.

The most notable appearance of the year was the abundance of plant lice on vegetation of all kinds in early summer. As one correspondent, at the end of a despairing letter, exclaimed, "even the weeds are lousy."

Many species, like those infesting apple, cherry, plum and other fruits, are found early in each year; but the first spell of hot, dry weather checks increase, and little is seen of them later. This season continued cold or wet almost until midsummer, and just so long the plant lice remained. As usual, the first hot, dry spell put a period to the trouble, but much damage was done on many plants and fruits.

Widespread attention was called to this invasion, because many shade trees in cities and towns were also infested. On the Norway maples the leaves became so coated with "honey dew" that they appeared to be varnished, and the walks beneath were coated with the stuff, which remained for weeks, in spite of the rains.

As a result of this unusual abundance of Aphids, there was a corresponding increase in their natural enemies. As the season advanced, parasitized plant lice seemed almost as abundant as the others, and when the check came, almost everything seemed to harbor parasites.

The Coccinellids, or lady-birds, became abundant as never before in my experience, and *Mysia 15-punctata*, the fifteen-spotted lady-bird, was more plentiful than I had seen it in all the years of my residence in New Brunswick combined. When the Aphids ceased to increase, the lady-birds were left without food, and began to devour each other, and in a short time nothing remained to show that there had been any unusual prevalence of plant lice and their enemies. But, while the weather favored certain normally harmless species, it checked others that are normally injurious. The melon louse, which did such disastrous work in 1895 and 1896, was not injurious anywhere; though it appeared at the usual time in sufficient numbers to cause alarm. There was no increase, however, and the vines were, later, entirely free.

Tomato lice again made their appearance in Salem county, but had vanished when I learned of their occurrence and wrote for specimens.

The *Strawberry root lice*, which were so troublesome in 1896, seem to have been absent in 1897, and the experiments that I had planned were, in consequence, abandoned.

The question of dealing with borers is important in our State, and one of the lines of work was experiments with wrappings, paints and washes to keep them out. Incidentally, a study of the peach borers was made and a bulletin prepared.

In line with this series was a study of the action of *Dendrolene*. The contradictory results obtained and the injury caused by it in certain cases, made it desirable to ascertain where the difficulty lay. The record of these experiments forms part of this report.

A few experiments were made with wire-worms. There was no intention of going very fully into the subject, because it has been carefully studied at the New York Station; but I was desirous of testing some of the results under different conditions, and wished also to test a variety of new substances as to their action on these insects.

This leads naturally to the question of insecticides in general, and of these quite a number were submitted to me for trial. My department is not well fitted for such tests on a large scale, and laboratory results are not always safe indications of what will happen in the field. Nevertheless, a number of interesting results were obtained, partly by the co-operation of correspondents, which will be found recorded elsewhere.

Many complaints reached me concerning the quality of the Paris green sold to our farmers, and it was freely suggested that much of it was adulterated. To test the question, samples were obtained, probably representing all the makes sold in the State, and these were analyzed by Professor W. S. Myers, at the request of the Director. These analyses and their results are also discussed in this report.

The trouble of making a kerosene emulsion has prevented many from using this very effective insecticide, and to obviate it the Deming Company, of Salem, Ohio, has introduced a combination pump for spraying kerosene and water in a mechanical mixture. Some satisfactory experiments were made with this pump and are hereinafter recorded.

It was intended to make this season the studies on the habits of the *Orthoptera* of the cranberry swamps that were planned for 1896, but here again weather conditions interfered, and practically no katydids were noticed on the bogs.

The *San José scale* has not become of less importance during the year and more time was devoted to it than to any one other species. As a whole the matter is in a more satisfactory condition than before, and while extermination is not now possible, control certainly is. Some orchards once badly infested are now in reasonably good shape, and only one may be said to be worse than before. On the other hand, new points of infestation have been discovered and there has been some spread. A full account of the observations and experiments is included in this report.

Cut-worms are still about as generally injurious as any one other pest, in spite of the fact that there is a perfect remedy for those who choose to use it. Of course many farmers do use the poisoned bran, and I have yet to learn of a case in which it was not effective; nevertheless there are many that prefer to complain and replant rather than to go to the trouble of preventing injury. They realize that a "stitch in time saves nine;" but there is a remote chance that the

single stitch may be unnecessary, and this chance they take—usually to their loss.

In 1896 some complaint was made of injury to strawberry plants from *Leaf rollers*. This became much worse during the spring of 1897 and many acres in Atlantic and Cape May counties were seriously injured. Blackberries and raspberries were also attacked, but these plants were not injured. The pest is one which has been troublesome to the extent of locally prohibiting strawberry culture in other States and a bulletin on the subject will be prepared.

Strawberry weevils were locally injurious. Most growers seem to accept the injury as something unavoidable, and it is, therefore, difficult to ascertain just how much damage has been done. No destructive measures are employed and a resort to varieties least subject to attack is generally practiced.

White grubs are reported as strawberry pests from several sources, but not as seriously injurious. They were occasionally troublesome in corn as well, but hardly to be considered as a very dangerous pest.

Potato beetles required as much attention as usual in most localities and were made the subject of a few experiments with insecticides, which are not all recorded. Nothing proved as satisfactory as Paris green, the remedy almost universally used by farmers. It still remains the practice to allow the late broods to mature unchecked that there may be an ample supply to furnish grounds for complaint the spring following.

The beetles feed more or less readily on most of the *Solanaceæ*, but it is unusual to find them, as was the case during the past season, attacking tomato vines in destructive numbers. A difficulty arose here, because the tomato plant is quite sensitive to Paris green and shows signs of severe injury from applications of even moderate strength. In these cases I recommended arsenate of lead and received no word of any harm caused by it to plants.

There was no trouble this year from blister beetles, but an entirely new species, a tortoise beetle, *Coptocycla clavata*, was reported from Deckertown in June. It destroyed the hills by cutting off the stalks or otherwise mutilating them. This insect was also found in Pennsylvania and Delaware, and seemed to occur naturally on *Physalis* or ground cherry.

Rose-chafers seem to be on the increase. There are more complaints than for some time past, and quite a variety of crops were

infested. Several vineyards in Atlantic county reported trouble, and this, while not of much importance in itself, becomes so when considered as evidence of the approach of another destructive period such as that which culminated in 1891.

For some years there has been increasing complaint of the tulip soft scale, *Lecanium tulipiferæ* Cook. It covers the twigs and branches so densely that the tree becomes very sensitive to the injury caused, readily dying back to the point of infestation. The scale is the largest of its kind occurring with us and peculiarly nasty to handle; hence the trees are often cut down as the most convenient way of ridding them of the scales.

Root web-worms have been unusually troublesome in some localities and many complaints were made.

Early in June I was surprised to learn of an outbreak of *Canker worms* near Mount Holly, and on June 5th I found a large apple orchard of old trees almost utterly defoliated. Most of the trees did not retain a vestige of leaf, fruit or blossom, and on all the crop was utterly lost. This is the first time I have had any knowledge of injury from this insect which is so well known and destructive in the more northern parts of the country.

Asparagus has suffered severely from asparagus beetles, and the new species, *Crioceris 12-punctata*, has become an appreciable factor. It now occurs throughout the State south of the shale, from the Atlantic coast to the Delaware. There may be a check to the northward distribution of the insect at this point, because little asparagus is grown on the shale or in the northern part of the State.

Cabbage worms, while less abundant than in 1896, were yet common, and did much injury in 1897. As a rule, the sufferers are those who hesitate to use Paris green, and there are yet many who cannot convince themselves that this is safe. As a matter of fact, those who are growing the best crops use Paris green with great success and absolute safety, and I see no reason to change the recommendations I have made in this matter.

Saw-flies and their larvæ have been unusually troublesome, and many forms not before noticed by me were locally abundant. The "currant worm" was in evidence, of course, and as destructive to gooseberries as to currants. For the first time in my experience the larva of the cranberry saw-fly was found on our bogs, under such circumstances as to make it probable that it is responsible for some mischief that has been charged to other creatures.

During midsummer the pretty larva of *Selandria caryæ*, appropriately called the "butternut woolly worm," attracted attention in several places on walnut. Specimens were sent from Plainfield, and others were brought in from the vicinity of New Brunswick. It was also reported from Elizabeth and from Burlington county, so that some quite uniform factor seems to have determined the appearance in numbers. Some trees were pretty well defoliated, but as the insects were nearly full-grown when first noticed I did not advise active treatment, and in a few days they disappeared.

In September word was received from Newark that large numbers of small, yellow caterpillars, about half an inch long, had almost stripped poplars and were attacking maples and other trees. These proved to be larvæ of a saw-fly not yet bred, and unknown to the Washington entomologists.

Bag worms were more destructive than ever before, particularly to garden and hedge plants. Arbor vitæ is especially liable to attack, and, if the insects are allowed to defoliate it, the plant is doomed. Many of the evergreens never recover when once entirely deprived of leaves, and this favorite hedge plant is one of them. The most satisfactory measure is a careful examination of the hedges each winter to discover any bags that may have found their way on it. These should be cut off and burned, leaving the plant safe for the ensuing season except as an occasional larva may wander to it from other sources. The insect spreads in the caterpillar stage only, hence prevention of injury is possible. Should any sacks escape and young bag-worms are found feeding, they can be readily destroyed by Paris green at the rate of 1 pound in 200 gallons of water. As arbor vitæ does not stand arsenic well, the arsenate of lead is safer and can be used in more effective strength, say 1 pound in 100 gallons of water.

Codling moths and *Plum curculios* are as abundant as ever, and have this year caused a severe money loss by reducing the grade of fruit in many orchards. There are altogether too many careless sprayers—men who spray their trees because it has become the proper thing to do, but do not exercise any judgment in the matter. They spray whenever they have time, and usually remark later that they cannot see much difference between the trees they sprayed and those they did not get time to do. A not unnatural result in view of the facts! I find that in the southern counties there is a partial second brood, which, as nothing is done to check it, provides a considerable number of hiber-

nating larvæ. Wherever possible, hogs or sheep should be allowed to run in an orchard until picking begins, and after that time everything should be kept picked up and marketed, destroyed or otherwise utilized.

Among other orchard insects that were complained of was the *round-headed apple borer.* This occurs all over the State, but is more troublesome on the lighter land, except when it attacks quince trees. These seem to be its favorite food north of the red-shale line, and it is almost impossible to grow them there on account of this borer. Nothing better than mechanical protection for the trunks has as yet offered itself, and nothing is simpler than wrapping with newspapers as recommended for peach trees.

Pear blister mites were common early in the season and later many leaves showed marks of their presence. Interestingly enough, the Keiffer, usually the most exempt of all varieties, suffers most from this pest—perhaps because of its succulent foliage.

Pear slugs were abundant in some localities and nursery stock was among the sufferers. These insects often increase considerably in large nursery blocks and render the plants unsightly without doing much actual injury.

Quite early in the fruit season specimens of the "fig-eater," *Allorhina nitida,* were sent from several localities, with complaints of their abundance, but no direct charges of actual injury. This is troublesome in the larval stage in lawns and grass lands and the occurrence of the adults in large numbers may presage larval injury later.

Procris americana has not been as abundant in Atlantic county vineyards as in 1896, but was several times reported. Spraying with Paris green to check it is now quite generally resorted to and proves successful.

Early in the season many specimens of maple leaves with *Phytoptus* galls were sent in, and I found in the woodlands some small trees in which the leaves were completely covered. No injury was done, but the occurrence is interesting as another example of an unusual increase.

Many other species were brought to my attention which do not merit special attention here. In fact, insects were unusually numerous in species, and many kinds were submitted for examination and report from all over the State.

Most of my work is, of necessity, done on the farms where the insects are causing injury, and this requires frequent absences. Between April 1st and October 1st, 1897, sixty-four days were, in whole or in part, spent in the field or in traveling.

At seven institute meetings, held under the direction of the State Board of Agriculture, illustrated lectures were delivered, and addresses were made before several County Boards and at the meeting of the State Board. A large stock of lantern slides—over seven hundred—has been accumulated, illustrating all the more common farm pests with structural details, injuries caused and other points of interest. The photographic feature of the department has been considerably developed and has become indispensable.

The correspondence has been as large as usual, and 1,500 pages of letter-books have been filled between January 1st, 1897, and December 31st, 1897, representing considerably more than that number of letters sent.

One bulletin, No. 121, on the Melon Louse and Harlequin Cabbage Bug, has been issued, the results of the investigations made in 1896 having been all included in the annual report for the Experiment Station and in the report made to the State Board of Agriculture.

The collections of the department have been greatly enlarged, and a number of boxes illustrating injurious species have been arranged. This, the museum feature, has been constantly kept in mind, and a very valuable series has been accumulated. I have been favored, as in the past, with the assistance of the members of the Newark and Philadelphia Entomological Societies, who have been liberal with such material as was needful for my department.

Special recognition is due to Mr. J. Turner Brakeley, of Bordentown, who has for several years furnished material from Ocean county, and has made interesting observations on certain wood-infesting species. During 1897 I have received an excellent lot of specimens illustrating larvæ, pupæ and adults of *Monohammus titillator*, as well as the borings made by them. He has also supplied very full notes on the habits of certain species of *Myrmeleonidæ*, or ant-lions, and has sent a large number of specimens.

Finally, the aid given by the Entomologist of the United States Department of Agriculture should be acknowledged. Dr. L. O. Howard and his assistants have given me help in the identification of

species, and have always responded freely to all requests for information. Thanks are also due to the department itself for electrotypes of some of the cuts used in this report.

PARIS GREEN AS AN INSECTICIDE.

Paris green is recognized as a necessity by every farmer who grows orchard fruits or certain field crops, and tons of it are used each year.

Much is wasted against insects which it cannot possibly affect, and is used on general principles in the vague hope that it may be of value. It is a violent poison, yet cases are rare where there is even a trace of evidence that injurious results have followed the use of the sprayed crops. Of late there has been much complaint that results have been very unequal, and there is no doubt that different brands of Paris green produce widely different effects on foliage and presumably on insects. In 1890 Mr. Charles S. Cathcart analyzed a sample of Paris green, furnished by me, and found it to contain a very high percentage of arsenious oxide—68.82 per cent. Several analyses have since been made at other stations and no two agree, while in some instances adulterations were discovered.

During June I applied to correspondents for samples, in dealers' boxes, of the material sold to farmers in their respective vicinities, and received some fifteen lots, representing the following manufacturers or dealers: Wetherell & Co., Philadelphia, sampled by Emmor Roberts, Moorestown, N. J.; John Lucas & Co., Philadelphia, sampled by J. Lawrence Lippincott, Riverton, N. J., and Horace Roberts, Moorestown, N. J., from stock of J. S. Collins & Son; Cawley, Clark & Co., Newark, N. J., sampled by Henry Pfeiffer, at Cologne, N. J., from the Grange stock, by D. D. Denise, at Freehold, N. J., from the Grange stock, by Franklin Dye, at Trenton, N. J., from the stock of C. Ribsam & Sons, and by myself, at New Brunswick, from stock of Skillman & Van Pelt; C. T. Raynolds & Co., New York, sampled by myself at New Brunswick, N. J., from stock of William Rust & Sons; Leggett & Brother, New York, sampled by myself at New Brunswick, from stock of William Rust & Sons; James A. Blanchard, New York, sampled by myself from stocks of Eastman, druggist, and Hall, florist; J. S. Anistaki, Trenton, N. J., sampled by Franklin Dye.

With three exceptions, these samples were one-pound boxes, with the manufacturer's label sealing the box intact. The prices ranged from 12 to 25 cents per pound, though 17 or 18 cents seemed to be usual.

Eleven of the samples were referred by the Director to Professor William S. Myers, Instructor in Chemistry at the State Agricultural College, from whom the following report was received:

NEW BRUNSWICK, N. J., July 2d, 1897.

SIR—The samples of Paris green submitted to me for analysis contain—

	Manufacturer.	Dealer.	As_2O_3.
1.	Wetherell & Co.	From manufacturer	64.88 per cent.
2.	John Lucas & Co.	J. S. Collins & Son	47.82 " "
3.	Unknown	J. S. Anistaki	56.19 " "
4.	Cawley, Clark & Co	C. Ribsam & Sons	68.59 " "
5.	C. T. Raynolds & Co.	Wm. Rust & Sons	58.44 " "
6.	Cawley, Clark & Co.	Freehold Grange	41.54 " "
7.	Robert Shoemaker	From manufacturer	56.03 " "
8	John Lucas & Co	J. S. Collins & Son	63.11 " "
9.	Jas. A. Blanchard (Lion Brand)	Hall, Florist	67.38 " "
10.	Jas. A. Blanchard (New Process)	Eastman, Druggist	66.41 " "
11	Leggett & Bro.	Wm. Rust & Sons	59.33 " "
	Theoretical for aceto arsenite		58 65 " "
	Theoretical for arsenite		52.94 " "
	" " " one authority		42 04 " " (?)
	Cathcart		68 82 " "
	Average in Massachusetts		59.94 " "

(Signed) WILLIAM S. MYERS.

To this is added the following comment:

The above results varying so widely, from 41.54 per cent. of arsenious oxide to 68.59 per cent., seemed difficult to undersand on first comparisons. According to the last edition of the *United States Dispensatory*, Paris green is the aceto-arsenite of copper. The theoretical percentage of arsenious oxide in it is 58.65. The Massachusetts Report for 1895 gives the average of a number of samples as 59.94 per cent., and Mr. Cathcart, in the New Jersey Experiment Station Report for 1890, who states that there are two compounds sold under the name of "Paris green," the arsenite, as well as the aceto-arsenite of copper, finds as high as 68.82 per cent. of arsenious

oxide in a sample. The arsenite of copper, according to Sharples (*Chemical News*, 35, 88–108), contains only 41.93 per cent. of arsenious oxide, but is subject to wide variation in composition and purity, depending upon the degree of concentration of the liquid from which the body is crystallized. With no water of crystallization, the arsenious oxide may run as high in the pure pigment as 52.95 per cent.

Bloxam and older authorities have published formulas requiring from 50 per cent. to 70 per cent. of arsenious oxide. According to Wagner, the other body, the aceto-arsenite of copper, is only an empirical formula in which the copper may exist as sub-oxide, and the arsenic be present as arsenate. Here is also an opportunity for considerable variation from the theoretical per cent. of 58.65. It is not, therefore, surprising to find wide variations in the commercial products, when we have three possible theoretical figures, viz., 41.93 per cent., 52.94 per cent., and 58.65 per cent., and when actual figures have been obtained as high as 59.94 per cent. and 68.82 per cent. We have no reason to believe, consequently, that the samples were adulterated.

(Signed) WILLIAM S. MYERS.

A variation of over 26 per cent. in the arsenic in two samples from Cawley, Clark & Co., and over 15 per cent. in two from John Lucas & Co., seemed too great to be due to accident, and despite the fact that no adulterant was found, I communicated the results to the manufacturers concerned—directly in one case, through the dealer in the other—requesting them to make any explanation they might deem fit under the circumstances.

July 14th Cawley, Clark & Co. answered in part as follows:

* * * "We beg to say that all of our green, whether sent out in bulk or small packages, is also absolutely free from adulteration, and is as uniform in composition as it is possible for us to make it. Of course, as the aceto-arsenite of copper is a somewhat indefinite compound, there will inevitably be some little difference between batch and batch, but this difference, for practical purposes, may be disregarded. If as we understand it, you have found a sample of our green analyzing only 41.54 per cent. arsenic, it must have been adulterated since it left our factory."

The low sample was from the stock of the Freehold Grange, and

was sampled by Mr. D. D. Denise, President of the New Jersey State Board of Agriculture. In response to further question as to the possibility of guaranteeing a given percentage of arsenic, Messrs. Cawley, Clark & Co. courteously answered further: "We may say once again, with as much emphasis as possible, that it is utterly impossible that our green should contain so low a percentage of arsenic as the one you found. There must be a mistake somewhere, or the green has been adulterated since it left our factory. We are surprised to learn that you would not consider a variation of five or six per cent., in arsenic content, between two boxes turned out by the same maker, to be even evidence of carelessness, as we do not see how it could be possible for such a great variation to occur, providing moderate care were taken and the same formula used all the time. We do not make many assays of our green, but we have made several at considerable intervals, and found the composition approximately constant. We have another check which confirms this, viz, by weighing each batch, and we find from given amounts of materials that the yield is sensibly constant. As our green is composed only of arsenious acid, copper oxide and combined acetic acid, a simple calculation will show you that the cost of production would be lessened by increasing the percentage of arsenic. We suppose it would be possible to give some such guarantee as the one you mention, but we do not think it would be of much practical importance as long as the green is pure, as, for reasons above mentioned, the manufacturer would endeavor to get as much arsenic into it as possible, consistently with making a good bright green. The guarantee might be stated thus: 'This green contains at least [so much] arsenic.' In this way small but inevitable variations might be covered."

It will be noted that these gentlemen are not inclined to admit the possibility of any great range of variation in the percentage of their product; but it is certain that no trace of any usual adulterant was found by Professor Myers in the low sample.

A somewhat different stand was taken by the Messrs. John Lucas & Co., in a letter addressed to J. S. Collins & Son, from whom both the samples analyzed were obtained. Their letter, dated July 15th, is in part as follows:

"The only explanation we could give you is found in the well-known fact that most tests or formulas for products rarely have a definite or absolute proportion assigned, or, in other words, consider-

able latitude is allowed, unless the product may be one that is little called for * * * The theoretical combination as stated by Mr. Smith is 58.65 per cent., but Paris green is made, as we presume you know, in large batches, five, ten or twenty tons, and at certain seasons of the year the manufacturer is urged to the utmost to turn it out fast enough, hence sufficient time is not given to the process or the variation would not be more than 5 per cent. either way as compared with the theory."

Though not directly so stated, these gentlemen admit the possibility of a variation as great as 15 per cent. in their product; but seem to consider it immaterial from a practical standpoint. In this I must dissent, for a difference of even 10 per cent. of arsenic may make all the difference between an effective and an ineffective application.

From all the facts obtainable, it seems certain that Paris green varies in the percentage of arsenic under the best conditions, and that it may be present either as an arsenite or as an arsenate. Manufactured in large quantities the difficulties in obtaining a satisfactory result increase, so that a difference of 25 per cent. may exist in an absolutely unadulterated product. It follows that, as has been practically found by farmers, the material is not reliable and results are not constant.

An alternative is in the use of the arsenate of lead, obtained by a combination of arsenate of soda and acetate of lead. These materials are definite in character, soluble in water, and may be mixed as required for use, so that an approximately uniform insecticide may be relied upon. It has the advantage of being harmless to foliage, and while it requires more in weight to attain the results than of Paris green, the cost is enough less, weight for weight, to balance matters.

Arsenate of lead is formed by dissolving arsenate of soda, four ounces, and acetate of lead, eleven ounces, and combining the solutions. A white precipitate will be formed, which settles very slowly, so that little stirring is required when the mixture is diluted for use. The quantity above given may be used in 100 gallons of water for most insects, in 80 gallons for more resistant forms, and in 50 gallons for potato beetles.

I strongly advise farmers to become familiar with this insecticide, because of the greater uniformity in results likely to be attained.

KEROSENE EMULSION SPRAYERS.

The effectiveness of kerosene as an insecticide is impaired by the difficulty of bringing it into proper condition to be applied. It will not mix directly with water, and until the "emulsion" was discovered its range of usefulness was small. Prof. A. J. Cook found, many years ago, that a small quantity of the oil would combine with strong, hot soapsuds; but it remained for Mr. H. G. Hubbard, working with the late Dr. C. V. Riley, to get a real emulsion, in which a large percentage of kerosene was permanently combined with soap into a form that could be diluted with water. The result was the "Riley-Hubbard" formula, which is as follows:

Hard soap, shaved fine	½ pound.
Water	1 gallon.
Kerosene	2 gallons.

Dissolve the soap in the water and add, boiling hot, to the kerosene, which should also be slightly warm. Churn with a force-pump, directing the discharge back into the bucket from which it is pumped, and the result will be a snow-white, butter-like mass. If the materials are sufficiently hot, five minutes of vigorous churning (pumping) produces a perfect emulsion, which will keep in a cool place for days or even weeks. This kerosene butter can be diluted with water to any desired extent.

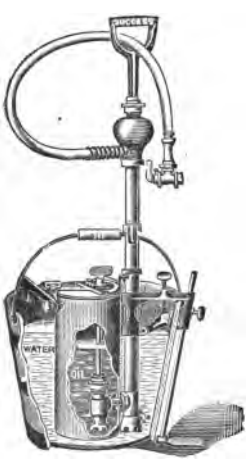

Fig. 2.

"Success" Kerosene Emulsion Sprayer, showing the mechanism. (From the Deming Co.)

It was soon found that "hard" water would not do for the emulsion, and that even a little hardness was fatal to success. It is difficult also to convince the farmer that "churning" means anything more violent than churning milk for butter, even where a force-pump is especially mentioned. Hence kerosene never became as popular as it deserved.

In 1891, Prof. E. S. Goff conceived the idea that a mechanical mixture of kerosene and water, in a finely-divided condition, would answer the purpose of an emulsion, and his experiments were so encouraging that they were taken up by others until, in 1894, Prof. H. E. Weed contrived a mechanism which made it possible to spray kerosene and water in somewhat reliable proportions.

The first pumps were unreliable; but errors in construction were rectified until the combination pumps now made by the Deming Company, Salem, Ohio, are quite satisfactory.

A "Success" Emulsion Sprayer, which is practically a bucket pump, with kerosene attachment, was used in a series of tests made in the laboratory to determine how much the constancy of the proportions could be relied upon.

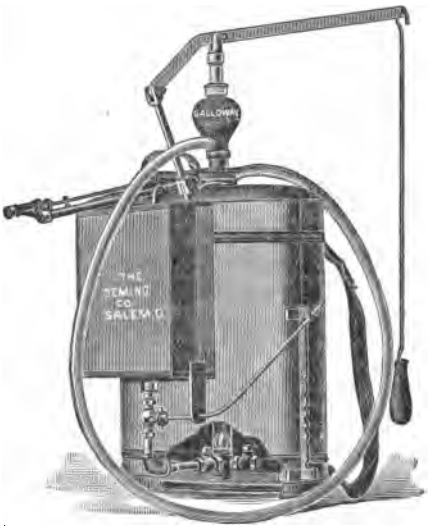

Fig. 3.
Perfected Galloway Knapsack Emulsion Sprayer.
(From the Deming Co.)

It was found at once that rapid changes were not allowable, and that the constancy when the kerosene was in large proportion, was much greater than when it was small. The experiments were all made by filling in rapid succession a series of graduates with the mixture as pumped through the nozzle, allowing the kerosene to rise to the top, and then measuring to ascertain the percentage.

At the rate of 1 to 20 the machine was utterly unreliable, this exact proportion never being obtained, while the range was all the way from 1 to 100, to 1 to 15.

At the index 1 to 15 the results varied much less and were as follows:

1 ff.....	Water.....	900 cc.....	Kerosene.....	90 cc.....	9.09	per cent.
2 ff.....	"	900 cc.....	"	160 cc	10.5	"
3 ff.....	"	670 cc	"	65 cc.....	8 8	"
4 ff.....	"	780 cc.....	"	80 cc.....	9.3	"
5 ff.....	"	775 cc.....	"	80 cc	9.35	"
6 ff.....	"	1,040 cc.....	"	105 cc.....	9.1	"
7 ff.....	"	970 cc	"	75 cc	7.2	"
8 ff.....	"	795 cc	"	65 cc.....	7.5	"
9 ff.....	"	430 cc.....	"	40 cc.....	8.5	"
10 ff.....	"	818 cc.....	"	67 cc	7.5	"
11 ff.....	"	800 cc.....	"	65 cc.....	7.3	"

At the index 1 to 10 and 2 to 10 the results were practically uniform and the pump could be considered reliable. All the experiments were duplicated at a different time with similar results.

Fig. 4.
"Peerless" Kerosene Emulsion Sprayer.
(From the Deming Co.)

In field tests on apple, cherry and plum trees the results were entirely satisfactory, the action of the sprayed mixture being uniform for the same strength.

I feel safe, therefore, in recommending these pumps wherever a mechanical mixture of kerosene and water is needed. They are made in three styles: First, the "Success," a bucket pump, as already mentioned; second, the "Perfected Galloway Knapsack Sprayer," in which an extra receptacle carrying one gallon of kerosene is added to the usual sprayer, and third, the "Peerless Kerosene Emulsion Sprayer," which is a large barrel pump for orchard work.

KEROSENE.

The value of kerosene as an insecticide has been frequently stated, but, while unquestionably effective against insects, it has been heretofore considered more or less injurious to plants, and the effort has been to get it as much diluted as was consistent with the desired effect on insects.

The advent of the San José scale, requiring the most powerful contact insecticides known to us, has brought up the question of the effect of the mixtures needed upon the plants. This point only is considered here, the effect upon the insects being incidental only.

The aim was to ascertain the effect of undiluted kerosene on plants and to determine the circumstances under which it could be safely used.

During the winter of 1896–1897 a number of bearing pear trees (Dwarf Duchess and Howell) on one of the Parry orchards were sprayed, first with a whale-oil soap solution and afterward, toward

spring, some were also treated with undiluted kerosene 110 per cent. test. There was not anywhere the least sign of injury of any kind during the summer. The trees developed normally and matured a rather light crop of fruit. When last examined, September 25th, they were becoming quite normally dormant, with a full set of fruit buds. The trees were rough barked, and they were left simply to try the effect of the kerosene.

February 17th, 1897, Mr. Howard G. Taylor treated seven Keiffer pear trees with one gallon of undiluted kerosene, putting it on with a brush.

June 12th found the treated trees in all respects in good condition. Other examinations were made during the season, the last on September 25th, when the kerosened trees were in thoroughly good condition in every respect.

The following is a record obtained by Mr. C. L. Marlatt, at the United States Department of Agriculture, in Bulletin 9, New Series:

"The discussion of this substance at the last meeting of the association [of economic entomologists] led to some additional experiments on our part with the use of pure coal oil or kerosene on plants. Various trees, including young and vigorous peach, pear, cherry and apple trees, euonymus bushes, and some old bearing peach trees, were thoroughly sprayed with pure kerosene early the past spring, with one exception, before the buds had begun to swell. In the case of two large bearing peach trees the blossom buds were swelling and opening, and these trees were also badly infested with *Diaspis lanatus*. The other plants, with the exception of the euonymus bushes, were healthy and free from all insects. Much to my surprise and astonishment, no ill effects of any moment resulted in the case of any of the trees sprayed with kerosene. In the case of all the trees, spraying was continued just long enough to moisten the plants thoroughly, but not to cause the oil to run down the trunks and collect about the base, and with the young trees the soil was carefully mounded up and pressed about the crown to avoid all danger of the oil collecting at that point.

"The pear trees treated, and also the peach, came out in full bloom, the opening of the blossom buds not being at all interfered with by the oil bath. After the bloom fell the peach trees treated with pure oil made much finer growth than untreated trees. This may have been in part due to the more favorable location of the trees, and pos-

sibly also to the fact that in the treatment with the coal oil the eggs of Aphides on the trees had been entirely killed, whereas on the untreated trees a very bad infestation with plant lice developed early and checked the growth of the trees, killing some of them. No Aphides, however, appeared on the sprayed trees. In the case of the pear trees particularly, and also the apple, the unfolding of the leaf buds was very noticeably delayed as compared with untreated plants, the buds seeming to open up much more slowly, and for two weeks at least the difference was very marked. Very soon thereafter, however, the treated trees overtopped the others both in abundance of foliage and amount of new growth, and at the present writing, July 20th, there seems to have been no injury whatever as a result of the treatment.

"The large peach tree sprayed showed no ill effects, and all of the scales on the tree were killed except where they had been protected in a few instances by masses of leaves webbed about the limbs. At least 99 per cent. of the scales were killed. On the euonymus a similar result was shown, at least 99 per cent. of scales having also been killed by the oil.

"These results are so greatly in contrast with those previously attained in the experiments conducted in practically the same way that it seems difficult to account for them. That spraying with pure oil will often kill trees cannot be doubted, even when applied in the dormant condition in winter, as demonstrated by experiments on a number of apple and peach trees two or three seasons ago. It is possible that with these earlier experiments the same care was not employed to prevent the collection of oil about the trunks of the trees and the trees were not mounded up, but the work was as carefully done as would ordinarily be the case in actual practice, and probably much more so. It is possible, therefore, that the death of the trees in some instances was due to the collection of the oil in the cavity formed about the trunk by the swaying of trees in the wind, which, as will be shown later, has had disastrous results in California with the emulsion even. Others have reported the use of oil on trees without bad effects, so that pure oil as an insecticide is one to be used with caution and with full appreciation of the fact that the death of the plant may result."

One other record comes from an Atlantic county orchard whose owner does not wish to figure in print. He writes: * * * "I can say we used pure kerosene with good effect, but care should be taken

when to use it and how to use it. We find by taking pure kerosene when the trees are frozen and giving the tree a thorough coating it will kill the scale without injuring the trees. It appears that the frozen surface does not let oil penetrate the bark of the tree. The above has been used with safety on young apple trees of different varieties and under the above conditions only. I have seen the same used on peach trees in the summer with fair effect, but I do not advise it. I have also seen it used on peach trees in the winter and it killed all the trees it was used on."

June 11th I used the kerosene emulsion on some cherry trees infested with plant lice, and incidentally sprayed a few suckers from a larger tree with undiluted kerosene. June 15th the pure kerosene had killed the plant lice and had not seriously harmed the suckers, a few leaves only turning black. In fact, the injury was not so great as that on the lice-infested trees, where the shoots were becoming brown and dry.

Mr. Howard G. Taylor wrote (June 16th): "On some Japan plums that were lousy and last year had some scale, I used pure kerosene, not caring if I killed them so that I killed the lice." July 12th he wrote: "I killed the lice on plum trees with pure coal oil, and nearly finished the trees at the same time."

July 15th Mr. Taylor said that while the plum trees seemed pretty badly injured, they were by no means dead. Later, all save two of the trees recovered completely, and in September were in full leaf and promising well for next season.

June 18th I applied kerosene (150° test) with an atomizer on a spiræa bush badly infested with plant lice.

June 22d all the plant lice had been killed and all the tips of the shoots as well. The older leaves were not injured, and a few days thereafter no trace of any bad effect was visible. In October the plant became normally dormant like its fellows.

June 18th some plants of purple beech and *Rosa rugosa*, at the Parry nurseries, were sprayed with undiluted kerosene. July 14th found absolutely no trace of injury of any kind on the purple beech, nor did any develop up to September 25th.

The Japanese rose had not fared so well. Two large plants had been sprayed, all the shoots, young and old, being fully covered. One plant was reasonably wet, the other thoroughly drenched. The

former showed a little yellowing of the older shoots, the latter had the old shoots decidedly yellowed. In both cases the young shoots continued vigorous.

September 16th there was no appreciable difference, but on the 25th of that month the old shoot, which had received the double dose, was brown and dry. It had matured its seed and kept up in all respects with the rest of the plants until a day or two ago, but it is now practically dead. None of the young shoots are in the least harmed, and the plant, as such, is uninjured.

July 15th two trees in the Taylor orchard, near Riverton, which had not been treated during the winter, were found badly infested with scales, and I asked Mr. Taylor to spray with kerosene, undiluted, which he did July 23d, "about two P. M., and bright sunshine at that time, but by four P. M. we had a heavy shower, or rather several, with high wind and a little gale. I used about one gallon on two trees, using a Vermorel nozzle."

August 7th I examined these trees and learned further that there had been a fresh breeze blowing, and that a third tree had been almost as well treated as the others on the wind side. Not the least trace of injury was observable anywhere, either on fruit, leaves or buds.

As Mr. Taylor seemed willing to risk things, I asked him to spray these same trees a second time a little later in the season. This was done about September 10th, and the trees were examined September 15th.

This time there was undoubted evidence of injury. Quite a number of leaves were burned, and some water sprouts have been killed. On this point there is some doubt, however; for these were broken, and the injury may not be all chargeable to the kerosene. But some of the tips have undoubtedly been injured, and some of the leaf buds near the extremities looked bad.

A third tree, which had been sprayed for the first time when the others were sprayed the second time, showed practically no injury. It is to be noted that all these were fruiting trees, and that the fruit, as well as the other parts of the tree, was sprayed.

September 25th the trees were again examined, and looked decidedly better than before. Some of the leaf buds had been killed, and probably some of the fruit buds as well; but there was not by any means any wholesale killing of buds. The tree sprayed once only showed no appreciable injury.

About July 15th a Duchesse pear tree bearing a small crop of fruit was sprayed in a Parry orchard, and on August 27th one limb of another bearing fruit was also sprayed.

September 16th the tree first sprayed was examined and found in no way harmed; the fruit was equal in development to the average, and nothing about the plant indicated that it had been the subject of experiment. The fruit was in all respects normal in flavor.

The tree treated August 27th had suffered no injury, but some of the buds were forcing, which, by-the-by, was not an unusual matter this season. The fruit had lost its flavor, however, and was flat, while the skin, if chewed, gave a vague taste of the oil to one who knew what had been used.

September 25th the trees were becoming normally dormant, the buds being all sound.

I had been gradually becoming more confident that kerosene would not cause the wholesale destruction that had been feared, and asked Mr. Horace Roberts, of Fellowship, to spray some trees of different varieties in his orchard. This he did August 14th, treating six trees each of plum, peach, pear and apple. August 19th no injury was perceptible, and when none appeared up to August 23d I was ready to send out the circular dated September 1st recommending the use of kerosene on scale-infested trees.

September 25th I examined the sprayed trees, finding not the least trace of injury of any kind. It is only fair to say, however, that neither was there the slightest evidence that even a single San José scale in any stage had been killed! The insects were present in all stages in as great abundance as on the untreated trees, and I would not have believed any man in whose veracity I had not perfect confidence who stated that these trees had been actually sprayed with kerosene. Under the ciocumstances, this experiment proved nothing. The oil used was of the household stock used in lamps.

August 23d, a more elaborate series of spraying was made at Parry on nursery trees to note the effect of kerosene, 110° test, on young plants.

Mr. Frank M. Bartram, in general charge of the nursery stock at Parry, assisted, and the notes on the condition of the plants August 30th and September 6th are his.

Plants Sprayed with Undiluted Kerosene August 27th, 1897.

PLUMS.—A group of nine or ten plants, three species.

August 30th. Edges of leaves and occasionally tips of branch blackened.

September 6th. Injury much more apparent, least on Domesticas, Japans next, Americana badly burned on young tips and leaves.

September 16. No new developments save that all of the plants are forcing the lateral buds; this is particularly true of Domestica. No serious harm has been done to any.

September 25th. Most of old leaves gone; the aggregation looks bad as a whole, yet all would probably recover if left.

JAPANESE CHESTNUT.—One example.

August 30th. No markings perceptible.

September 6th. A very few leaves partly blackened.

September 16th. No apparent injury—the blackened leaves have either recovered or fallen.

September 25th. Nothing new to be noted.

CITRUS TRIFOLIATA.—A small row.

August 30th. No markings perceptible.

September 6th. No markings perceptible.

September 16th. A few tips apparently killed, but this may not be due to the kerosene, because there was more or less of the same appearance on the entire plot. Some of the old leaves have fallen, but unless attention was especially directed to it no difference from unsprayed plants would be observed.

September 25th. Nothing new to be added.

ROCKY MOUNTAIN CHERRY.—Four examples.

August 30th. Leaves very considerably curled.

September 6th. Defoliated, branches appear somewhat injured, may recover.

September 16th. One plant dead clean to the root; the others are all forcing the dormant buds and becoming covered with new foliage.

September 25th. Tips of branches dead down to the shoots.

CRANDALL CURRANT.—Several plants.

August 30th. No perceptible change; many leaves had fallen before spraying.

September 6th. No perceptible change.

September 16th. Most of the old leaves gone and the dormant buds are developing everywhere.

September 25th. Nothing new to report, except that the forcing of the dormant buds is now quite general on unsprayed plants, and not to be altogether charged to the kerosene.

ELEAGNUS LONGIPES.—Two or three plants.

August 30th. Some young leaves curled.

September 6th. Many leaves, especially younger, dropped; some others burned.

September 16th. Leaves seemed to be still dying, but all the buds are good, and some of them are starting.

September 25th. Nothing new.

BLACK WALNUT.—One tree.

August 30th. Some young leaves curled.

September 6th. Many leaves, especially younger, dropped, some others burned.

September 16th. Leaves partly blackened; new shoots starting.

September 25th. Nothing new.

FILBERT.—Several plants.

August 30th. Leaves burned.

September 6th. Leaves burned considerably.

September 16th. No trace of injury now apparent, and the plant seems in a normally dormant stage.

September 25th. No new developments.

PYRUS JAPONICA.—Four plants, one of them containing a fruit, which is to be sent me after two or three days, and was sent.

August 30th. A few leaves blackened and curled; fruit burned on sunny side.

September 6th. Almost defoliated.

September 16th. All leaves gone, but falling on unsprayed plants as well; the buds all seem sound and there is no second growth.

September 25th. Matters still as before.

KEIFFER PEAR.—Several plants.
August 30th. No perceptible effects.
September 6th. No perceptible effects.
September 16th. No perceptible effects.
September 25th. No perceptible effects.

KOONTZ PEAR.—Several plants.
August 30th. Leaves blackened.
September 6th. Appearance same as on August 30th. No apparent development of injury.
September 16th. Leaves mostly gone; all the new buds are developing.
September 25th. Almost dormant; new shoots at a standstill.

CHAMPION QUINCE.—Several plants.
August 30th. Leaves slightly blackened.
September 6th. Leaves much more blackened.
September 16th. Leaves dropped; new shoots are growing vigorously.
September 25th. No new developments.

MONTMORENCY CHERRY.—Several plants.
August 30th. Leaves very slightly curled.
September 6th. Leaves very considerably burned and dropped.
September 16th. New shoots are developing rapidly.
September 25th. No new developments.

STARR APPLE.—Several plants.
August 30th. Leaves slightly blackened.
September 6th. Leaves more apparently injured.
September 16th. Terminal buds killed—the lateral buds are developing.
September 25th. Nothing new noted.

CARLO APPLE.—Several plants.
August 30th. Leaves very slightly blackened.
September 6th. Leaves much more blackened and rendered useless to tree.
September 16th. Some harm done, not much; new shoots are developing; the broken shoots are darker than normal almost to the trunk.
September 25th. Nothing new.

JAPANESE WALNUT.—One plant.

August 30th. No perceptible effects.

September 6th. Foliage somewhat burned, not to a serious extent.

September 16th. Serious injury caused by kerosene lodging at base of leaf stalks and soaking into the branch there; tissue killed at all such points.

September 25th. Injury intensified.

PEACH.—Several plants (Wonderful, Yellow Freestone).

August 30th. Leaves perceptibly blackened, most apparent of any tree sprayed.

September 6th. Leaves much injured, and growth, for time being at least, entirely checked.

September 16th. Signs of injury almost all gone; shoots that were apparently dead have plumped out again, and there seems much less harm than indicated ten days ago.

September 25th. Hardly distinguishable from unsprayed trees. Some specimens of apple and peach were broken or cut to allow the kerosene to penetrate into the wood. A special note should be made of the condition of these plants.

August 30th. Leaves on cut shoots dead, somewhat appearance of twig dying back.

September 6th. Defoliated, but signs of injury to shoots not nearly so apparent as when before noted; seem likely to become same as shoots not cut.

The notes on September 16th and 25th were made by me, after consultation with Mr. Bartram.

The most noticeable effect was in the forcing of dormant buds; but some of this was apparent even on untreated trees. The season was a bad one, wet, cold weather lasting until well along in summer, followed by great heat in August, and finally by drouthy conditions, which matured the foliage before the trees were ready to become dormant. So in early October a second crop of apple and pear blossoms was not an unusual sight, and forcing was very common. However, there was no doubt that the kerosene had hastened matters, and that much of the forcing of dormant buds could be fairly chargeable to it. The date of the spraying was evidently a bad one under the circumstances, since the functions of the almost mature leaves had been so checked that the plant, in its effort to mature the wood,

developed the buds that would otherwise have become dormant. But this was not so in all cases. It seems also that the appearance of injury is most severe about two weeks after the spraying. Mr. Bartram informed me September 16th that peaches looked very decidedly better than when previously examined. Shoots that he had then supposed were killed had plumped out again and were apparently doing well. Only Rocky Mountain cherry and plum showed dead plants, and these seemed to be the most susceptible of those treated.

Severe injury was also caused on Japanese walnut which may result in the death of the tree in whole or in part. Here the kerosene lodged at the base of the leaf-stalks and worked into the plant tissue, destroying it below the leaf-stalk. The somewhat fuzzy character of the stalk facilitated this chance of injury. Evidently kerosene cannot be safely applied here. The fact that the trees in the block were quite large and formed a dense shade may have had something to do with the matter by retarding evaporation, and this brings up the most important of all the points in the use of undiluted kerosene, already mentioned by Mr. Kelsey in the letter printed in my last report. The kerosene, to be safe on active, growing plants—perhaps even on dormant plants—should be applied in such a way and at such a time as to give the best possible opportunity for rapid evaporation. Possibly contradictory results may be explained in some cases by a failure to recognize this factor.

September 25th Professor G. Harold Powell, of the Delaware Station, accompanied me to the Parry, Taylor and Roberts places and seemed so impressed with this point which his own observations brought out that he tried a series of experiments on his return to Dover, concerning which he wrote October 5th: "I looked over the trees again after your letter came, and I can find no harm to those sprayed with kerosene, when the work was done on a bright, windy day. The trees include Satsuma plum, peach, apple and Duchesse pear. They still retain their foliage as well as unsprayed trees, and the scales, so far as I can find, are absolutely dead. On one peach tree that was yellow with the young scale when sprayed, there is not a living young to be seen, nor have I found an old one alive. I cannot say how next year's buds will come out, but at the present time there is no apparent injury to any of them.

"Trees that were sprayed on a bright, still day, including the same as above, show more effect from the treatment. The peach and plums

of the Miner group of *Prunus hortulana* are defoliated, but the apple and pear were only slightly scorched. I cannot say that the defoliated trees are permanently injured, but I expect to see some injury to the peach, as the wood seems a little shriveled.

"Peaches and plums of the Miner group were defoliated with kerosene diluted two to ten and three to ten, and partially scorched at one to ten.

"I shall not hesitate to use the kerosene on pear and apple where heroic treatment is needed, but I am afraid of it for the peach and the thinner-leaved plums. I also should not hesitate with the Japanese plums or native of *P. americana* or *P. nigra*."

October 15th Prof. Powell informed me that matters still looked as well as before, and no further injury had developed.

The evidence above given seems sufficient, all things considered, to warrant me in recommending the use of kerosene, when necessary, on most fruit trees, dormant or active, under the following restrictions:

It must be applied in a fine spray, so as to cover quickly and thoroughly; or, if painted on in winter, it should be put on as lightly as is consistent with thoroughness. A thin film covering everything is all that is needed.

It must not be put on in damp or heavy weather, or when there is any condition preventing evaporation. The best time is between 9 A. M. and 4 P. M. of a bright, dry day, when a light or even moderately-strong wind is stirring.

I would recommend oil of 150° rather than of 110° test.

As to the cases in which its application is indicated, this is not the place to speak. Further information on that point will be found in the essay on the San José scale.

EXPERIMENTS WITH DENDROLENE.

This material was tested in competition with Raupenleim in 1895, in an effort to obtain something that might be used to prevent the exit from the trees of adult sinuate pear borers, and the entrance of their larvæ into such as were yet uninfested. Raupenleim was supplied by the importers, Wm. Menzel & Son, and Dendrolene was purchased from Mr. F. L. Nason, who attempted to duplicate the imported substance at less cost. Both materials were subjected to certain preliminary tests, resulting in the determination that both were neutral, hence no corrosive injury was to be apprehended.

Consultation was had with Dr. Halsted and with experienced growers as to possible dangers, and I was advised that theoretically none was indicated except on active, green shoots.

Raupenleim is a well-known German tree protector, much used in forests to prevent injury by mice, rabbits, deer and the like and this was relied upon, as was also the experience of the Gypsy Moth Committee in Massachusetts, which has employed it to prevent the ascent of larvæ in some cases.

Dendrolene is not exactly like Raupenleim. There is a tarry material in the European product which causes it to harden on the application of continuous heat after first becoming fluid. The Dendrolene becomes soft, but never hardens, and is, therefore, theoretically a better material. The mechanical character is similar, free from grit, and both can be rubbed up completely between the fingers like heavy vaseline, leaving only a brown stain. Tested for light oils, nothing inflammable was found, and, in fact, the material on a glass rod held in the flame of a Bunsen burner failed to ignite.

A few preliminary trials were made to test immediate effects. Growing shoots of various shrubs were smeared and buds unopened or partly opened were covered. All unopened buds were killed. All partly opened buds continued to open. Shoots entirely covered failed to leaf out. Where the buds were left free the leaves appeared. Leaves covered on both sides died in a day or two. Leaves covered on one side only lived for some time thereafter. Covering a large branch did not affect the smaller ones starting from it. Altogether the results did not discourage a field trial.

Some of the Dendrolene was sent to Parry, to be used on nursery stock, which was to be entirely coated. The test resulted in the death of the trees as recorded in Bulletin No. 111. Field trials were made at Irvington on pear trees and at New Brunswick on a large lot of peach trees protected from borers by its use. At the end of the season no injury was apparent and so it was reported, while as a protection from borers it was perfect. In the spring following (1896) Mr. White was so well convinced of its value that he ordered sufficient to treat several thousand trees. Not until a considerable amount had been applied was it noted that some, treated the previous spring, had been checked in growth and that the bark seemed killed by the penetration of the greasy material. On the Durand place, at Irvington, it was still reported that no injury to

treated trees had been caused. It is to be noted, however, that the young trees treated in this orchard had received Raupenleim as a trial coat. Investigation at this time developed the fact that the Raupenleim had dried and become hard, forming a tar-like coating on the surface. The Dendrolene was still soft and greasy, but the grease had also penetrated the tissue and had killed the plant cells as far as it extended, not by any corrosive action but by simply filling the cells and displacing the normal contents.

The proprietors of the Dendrolene were at once notified of these observations and advised of the danger of recommending applications to young trees, especially peach.

As soon as he satisfied himself that Dendrolene was liable to injure young trees, Mr. White scraped off all that had been already applied, cleaned what remained of the previous application, and hilled up so as to cover the injured spots. The younger trees were also washed with a potash solution to remove all trace of Dendrolene. The trees all recovered and were showing no signs of injury June 16th, 1897, more than a year after the above treatment.

To be certain that Dendrolene was the only factor concerned, Mr. White gave one healthy tree a heavy coating around the base. This tree was dead in the spring of 1897, and so injured beneath the point where Dendrolene was applied that there could be no reasonable doubt as to the cause of death.

Experiments in 1897.

April 23d, 24th, 25th and 26th six ounces of Dendrolene were heated for ten hours continuously each day, in a porcelain dish over a water bath kept constantly boiling. At the end of the first day it was slightly more pasty than at first. At the end of the second day it was of a thick, syrupy consistency; at the end of the third day it was quite fluid and dropped readily from the end of a glass rod. No change was produced by the fourth day's boiling, and it was therefore assumed that no further thinning out would occur. It did not thicken again, even after standing several weeks. The material was tested several times to see whether inflammable vapors were given off, with negative results, and it refused to burn however tested. To test penetration, a drop was placed on a piece of stout manilla wrapping paper at the end of the first day, diameter of spot five-sixteenths inch; thirty-six hours thereafter it had formed a greasy spot one and a half

inches in diameter. After ten days the greasy patch measured one and three-quarter inches by two inches, and did not grow further. Several duplicates gave similar results. For about one-eighth inch around the central spot a slight deposit of thicker material occurs, and a ring one and a half inches in diameter is somewhat darker than the soaked space beyond it.

Another series of five drops, diameter one-quarter inch, was placed at end of second day. After twenty-four hours the soaked circle was one and a half inches, and at the end of ten days two inches in diameter.

Six drops were placed at the end of the third day, each one-quarter inch in diameter. After twenty-four hours they were one and a quarter inches, and in ten days two and a half inches in diameter.

At the end of the fourth day a drop one-quarter inch in diameter penetrated from two and three-quarters to three inches in ten days.

This seems to prove that under the influence of continuous heat Dendrolene becomes thinner and more penetrating, while remaining entirely neutral in reaction. The thinning continues even if the application of heat is intermittent, and the material never regains its former consistency. It simply becomes more penetrating and if the bark upon which it is applied is not sufficient to absorb it all, it will enter the living tissue below. In cold weather, or so long as the material retains it normal consistency, its power to penetrate is slight; but it does not evaporate, does not thicken in any way, and even when it can penetrate no further, the remaining sediment is yet greasy. All these would be valuable features but for the deleterious effect on the plant tissues.

When these physical properties of the material were well understood I made the following experiments to see whether the penetrating effect could not be neutralized while the protective effect was retained.

"D. & G.," Dendrolene and gypsum; a mixture of two parts by weight of Dendrolene and onepart land plaster thoroughly mingled

"D. & L.," Dendrolene and carbonate of lime; two parts by weight of the former to one of the latter. The carbonate of lime is a waste product sent to the Station for experimental purposes.

"D.," Dendrolene, without admixture. "R.," Raupenleim, without admixture.

These were all applied to wild cherry and Cratægus, forming, with

witchhazel, a dense hedge on one side of the College Farm. In each case both kinds of plants were given a complete ring of the material around a small or medium-sized trunk, around a branch and around a twig. One or more large patches were also plastered on large tree trunks, each application being labeled with tags lettered as above to indicate the character of the application made.

The thinned-out material was applied to wild cherry only, with a brush. All other applications were made with a trowel and were excessive in quantity, an even coat one-quarter inch over the rough bark being put on in all cases.

All applications were made May 3d, 1897, were examined twice during the summer and the condition of coatings and trees was carefully noted October 4th, five months after the application.

The thinned-out material had left only a slight greasy residue and had killed the branches to which it was applied. The substance had penetrated the thick bark and had killed the cambium layer beneath.

The Raupenleim was now, in all cases, a hard, tarry crust, retaining yet a little stickiness where it was thickest. No injury was noted beneath the bark in any case, and even the youngest shoots held their leaves as well as their untreated neighbors.

"D. & G.," Dendrolene and gypsum, was on fifteen plants, none of which showed any trace of injury. In all cases the bark was sliced down from two or more inches above to four or more inches below the application, and the appearance of the layers and the sap wood was noted. In no case had there been any penetration through even the outer layer. The mixture was quite dry on the surface and not in the least sticky, but in every case the coating was as complete as when first put on. As a mechanical coating it was perfect, but as a barrier to prevent insects from climbing up the trunk it had become useless. No check in growth was noticeable beneath the material in any case, even in two-year-old suckers, around the base of an old wild cherry tree.

"D. & L.," Dendrolene and carbonate of lime, gave exactly the same result.

Dendrolene alone had penetrated to some extent through the outer bark of young wild cherry trees in almost every case, but had caused no harm as yet. The material was apparently of the same consistency as when first applied, and further penetration and the extension of the little brown spots in the cambium layer might be looked for. The

worst case was a tree three inches in diameter at the outer edge, where it received the full benefit of the sun, and this had a considerable area of brown in the cambium layer.

On the other hand, an old tree, nearly twenty inches in diameter, was smeared on one side, the material being fully one-quarter inch thick in the thinnest part. This was just as good as when first put on, and of apparently the same consistency. There was absolutely no sign of abnormal appearance in the bark below this band, and no indication of any penetration through even the outer layer. It is to be noted in this connection that probably no ray of direct sunlight reached this smeared space since it was put on.

On Cratægus there was no sign of injury except on the youngest shoot, where the green inner bark layer was changing to yellow.

Briefly stated, Raupenleim did no apparent injury wherever applied, nor did Dendrolene, when mixed with gypsum or carbonate of lime. Dendrolene, without admixture, was injurious to young, thin-barked trees and shoots, but harmless on the thicker bark of large trees.

The weak point in this experiment is that nearly all the applications were unusually well shaded and not exposed to the heat and thinning action of direct sunlight. It is also unfortunate that the subjects were not usual orchard trees.

The conclusions that may be based on the experience gained since Raupenleim and Dendrolene were first used against the sinuate pear borer in 1895, are about as follows:

"Raupenleim" is more sticky than "Dendrolene." It forms a more perfect barrier to climbing insects, but chills in a cold atmosphere sufficient to allow caterpillars to pass over it safely, and under the action of heat first thins out a little and then becomes hard and tar-like, forming a crust which cracks and breaks as the tree increases in size. It is probably quite safe and will last several weeks in moderate weather.

"Dendrolene" is less sticky and more greasy than "Raupenleim," does not chill in a cold temperature, and never becomes hard or forms a crust. Therefore, it does not crack, and a heavy coating will remain intact for months. It thins under the action of heat, and becomes more penetrating, slowly working its way into the plant cells until all absorbed. If there is a sufficient thickness of dry or scaly bark to absorb all this greasy matter, no harm will be done; if not,

the living cells will be invaded and their normal moisture will be replaced by the Dendrolene. This action is continuous so long as anything remains unabsorbed.

The addition of some absorbent, like land plaster—road dust would probably answer quite as well—prevents ill effects to the plant, but seriously lessens the stickiness and leaves it available as a mechanical coating only to keep off borers and the like.

On young, thin-barked trees its use is not recommended in any case. On old, rough-barked trees the Dendrolene mixed with half its weight of land plaster will be safe as an application to keep out borers. *Except* that it is by no means certain that a complete exclusion of sun and air from any part of a tree trunk of moderate age, no matter what the nature of the excluding substance, will not prove more or less injurious.

I would not now advise any application of any kind of impervious material to remain continuously. In all cases I would recommend the removal of the protecting substance when the danger against which it is guarded is over.

WHALE-OIL SOAP.

Whale-oil soap, as an insecticide, has of late been especially urged for use as against the San Joeé scale. It was soon found that much worthless stuff was sold as "whale-oil" soap, and that, as a matter of fact, whale oil was rarely present even in the best samples. Fish oil of all kinds is employed, and practically only the refuse is used for soap. It was also found impossible to spray the soaps usually sold, when dissolved at the rate of two pounds in one gallon of water, because they would "jelly" on cooling, either at once or on standing a short time.

Experiments were accordingly made in the Divisions of Entomology, United States Department of Agriculture, and the results were presented by Mr. C. L. Marlatt, at the meeting of the Association of Economic Entomologists, at Buffalo, in 1896. Mr. Marlatt showed that most of the brands on the market were unreliable and indicated that soda is inferior to potash as an emulsifying agent for insecticide soaps.

At his request, Mr. James Good, of Philadelphia, made a potash soap, which fulfilled the requirments for an insecticide, and this was recommended as reliable. In consequence a great deal of "Good's

Potash Soap No. 3," was employed during the winter of 1896–97, and it was generally recommended by entomologists.

I had, in my experiments with whale-oil soap, employed the Anchor brand, sold by Leggett & Brother, of New York City, and found it entirely satisfactory; and so I stated, recommending this on the basis of the results obtained by myself.

The soap made by Good costs three and a half cents per pound in barrel lots. That made by Leggett & Brother costs four cents in similar quantity, and a wash containing two pounds in one gallon of water is distinctly expensive.

A soap made according to the following formula was recommended as cheap and reliable:

Concentrated potash lye	3½ pounds.
Water	7½ gallons.
Fish oil	1 gallon.

Dissolve the lye in boiling water, and to the boiling solution add the fish oil; continue boiling for two hours and then allow to cool. Any grade or kind of fish oil will answer and "sturgeon" or "menhaden" oil is usually employed.

Results during the winter of 1896–97, on the San José scale were not all that could be desired, and it developed that even the "Good" soap was not uniform in character or effect. According to those that used it, it differed in color and consistency in different lots, and worse than all, in its effects. Some lots were quite effective against the scale and some were not so. There was also a difference in the effect on the trees, and in some cases considerable injury was caused. I had no experiments under personal observation, hence cannot speak from my own knowledge, and simply repeat the complaints made to me without meaning to assert that the fault may not have been elsewhere than in the soap.

April 10th Mr. Charles Parry asked for the percentage of potash in the Good soap as bearing on the question of the cost of the material. As he put it: "The home-made soap costs less than one cent per pound. The Good soap costs three and one-half cents per pound. The question is, which is the cheapest in the long run?"

A pint bottle of soap made after the formula above given was sent me and proved to be scarcely even a soft-soap. After it was thoroughly shaken up it could be poured from the bottle like thin syrup. Mr.

James Good sent me for experimental purposes a pail of his soap, from which a sample was taken for comparison. This was a rather thin soft-soap, but could not be poured like the other.

For further comparison I obtained a sample of soap made by Mr. Henry Pfeiffer, of Cologne, Atlantic county, with the Pennsylvania Salt Company's lye according to their formula. Menhaden oil was used, and this was much like the Leggett soap, of which I used a sample similar to that employed in my work in the Jessup orchard as stated in the last report.

All these samples were submitted to Mr. Louis A. Voorhees, Chief Chemist of the State Station, who kindly tested them all for alkalinity, irrespective of whether soda or potash was the agent. He listed the samples as follows:

No. 210. Good's Potash Whale-oil Soap No. 3.
No. 211. Whale-oil soap, Richardson formula.
No. 212. Whale-oil soap made by H. Pfeiffer.
No. 213. Anchor brand whale-oil soap, Leggett & Brother.

The results were:

AS RECEIVED.

	No. 210.	No. 211.	No. 212.	No. 213.
Equal to normal alkali	1.8844	1.2229	2.4754	1.9035
Equal to potash lye	10.55 p. c.	6.86 p. c.	13.86 p. c.	10.66 p. c.
Equal to soda lye	7.54 "	4.89 "	9.90 "	7.61 "

AFTER DRYING.

	No. 210.	No. 211.	No. 212.	No. 213.
Loss of moisture	27.30 p. c.	71.58 p. c.	6.22 p. c.	6.25 p. c.
Equal to normal alkali	2.5920	4.3029	2.6393	2.0304
Equal to potash lye	14.52 p. c.	24.10 p. c.	14.78 p c.	11.37 p. c.
Equal to soda lye	10.37 "	17.21 "	10.56 "	8.12 "

A brief study of this table is interesting. The Leggett and Pfeiffer soaps are of almost exactly the same consistency; in fact, the difference of .03 per cent. between them is so slight that it can be disregarded. Both are hard soaps, and strictly comparable. As the question was only on the amount of the alkali, the percentage present was determined on the basis of either potash or soda lye, and there is a difference of over 3 per cent. in favor of the home-made product. That is, the latter is decidedly more caustic, and where as much as

two pounds are used in one gallon of water, the difference in effectiveness may be expected to be quite well marked.

Mr. Pfeiffer has furnished the following data as to the cost of the material made by him:

Five gallons of fish oil at twenty-five cents	$1 25
Concentrated lye, sixteen pounds, at eight cents	1 28
Making forty-five pounds of soap, costing for material	$2 53

This was boiled in a fifteen-gallon boiler in four lots.

Cost of wood	$0 63
Time of boiling, one and one-half days	1 88
Total cost forty-five pounds soap	$5 04

"By using a larger boiler, cost of boiling could be very much reduced, and the material can be bought much cheaper in larger lots."

Nevertheless, the above does not make a good showing, when the Leggett soap could be purchased for less than $2 for the same quantity.

The Good and Richardson soaps are also comparable, but less satisfactorily, because of the difference in consistency. Both are soft soaps, but while the loss on the Good soap, on drying, was 27.30 per cent., that of the other equaled 71.58 per cent. The amount of caustic in the Good soap, as received, was 10.55 per cent. if potash, or 7.54 per cent. if soda, while in the Richardson soap it was 6.86 per cent. if potash, or 4.89 per cent. if soda; a very heavy balance in favor of the Good soap. We get a different result, however, after drying, for here the Richardson soap turns out 24.10 per cent. of potash, or 17.21 per cent. of soda, as against 14.52 per cent. of potash, or 10.37 per cent. of soda. This means that had the Richardson soap been boiled down to the consistency of the Good soap, it would have shown a much better result.

As to the emulsifying agent, all the soaps contain potash, though not all potash in two cases. This was conclusively shown in the flame when the animal matter was burned off to get the ash. Another point of interest is that the Good and Leggett soaps, despite their different texture, are almost exactly alike in alkalinity. As received, the Good soap contains 10.55 per cent. of potash or 7.54 per cent. of soda as against 10.66 per cent. of potash or 7.61 per cent. of soda in the Leggett sample. Mr. Voorhees informs me that these differences

are within the range of experimental error, and that in two analyses of the same sample these results would be considered sufficiently alike. This means that pound for pound the two soaps should give equal results as an insecticide.

The question not settled here is whether the soaps are always uniform, and on this point the manufacturer must be relied upon. I still believe that the best way to obtain uniform results is in the preparation of the soap by the farmer himself, using always exact quantities of material and boiling down to the same consistency. The latter is important, because if soap is used by weight, the amount of water in the product must be approximately the same to obtain spraying mixtures of similar strength.

Two of the samples, that made by Mr. Pfeiffer and the Anchor brand, were evidently soda soaps, though both contained some potash, and the question arose whether there is any real advantage in potash. The Leggett soap is undoubtedly effective. My experiments and the experience of others prove that. The lye used by Mr. Pfeiffer is nearly all soda, yet the soap made by him was as effective as either the Good or the Richardson soaps, in which potash is undoubtedly used.

Caustic potash absorbs water readily from the air or from any tissue, animal or vegetable, upon which it is placed, and continues to do so until it has absorbed enough carbonic acid to form a carbonate.

Caustic soda has much less affinity for water, and changes much more readily to a carbonate which has no corrosive effect. Theoretically, therefore, potash should be best, particularly as a larger quantity is required to do the same work. This is shown in the tables, where, for instance, in sample No. 210, as received, Mr. Voorhees declares the alkali to be 10.55 per cent. if potash, and only 7.54 per cent. if soda.

On the other hand, a potash soap is more soluble and washes more easily, so that a considerable amount of moisture in the air or a washing rain would destroy its effectiveness. Containing a smaller percentage of mineral and a correspondingly greater quantity of oil, the soda soap is less soluble and forms a more tenacious coating, which might be expected to be more lasting and effective.

These are theoretical considerations, but they have a practical bearing, and lead to the suggestion that where a mere clogging effect is desired the soda soap is better because it contains more oil. Further,

in any case, and particularly with the potash soap, trees should be treated for the San José scale during a dry spell. I am inclined to believe that some of the differences observed in the effects of the same brand of soap are due to a difference in weather conditions. It is not necessary that it should actually rain; a mere excess of moisture in the air might easily affect an application unfavorably, especially of a potash soap.

As to the insecticide effects of the soaps, nothing new can be added. It was my intention to test the Good soap on the melon louse, but before any applications were necessary adverse weather conditions checked the insects.

So far as reports go, it has been very effective against plant lice of all kinds, but the data are not sufficiently definite to be made use of here.

THE SAN JOSE SCALE.

(*Aspidiotus perniciosus* Comst.)

The menace of this species to fruit culture has been brought out in previous reports, and its importance may be realized when it is understood that it has practically monopolized the attention of the entomologists of five, if not six States, and has given rise to more actual and attempted legislation than any similar pest in past history. A convention held in Washington, D. C., March 5th, was brought together chiefly because of apprehended injury from this insect, and national legislation is to be invoked in the attempt to deal with it.

New Jersey has come in for considerable abuse and distrust, because of the unfortunate fact that much of the distribution in the Eastern States was from nurseries in this State. As a matter of fact, serious infestation occurs with us in Burlington county only. There are several small centers in Atlantic and Monmouth counties; one, possibly two, in Mercer county; a few in Gloucester and Camden counties, one in Jersey City, and possibly one or two in Ocean county.

A case has occurred in Middlesex county, which has been eradicated, another was reported from Essex county, and some infested trees were sent into Hunterdon, Warren and Morris counties, where the scale seems to have died out in each case. I do not know of a single infested orchard north of the red-shale line, and there is no scale in any nursery there, so far as I have been able to find.

In Burlington county the infestation is probably quite general and more widespread than is realized, and probably some scaly localities in Gloucester county are yet unknown to me. From Burlington to Camden there is a succession of towns at short intervals, and in all of these are many gardens, large and small, containing trees, and with sometimes quite a variety of fruit trees. Small fruits, roses, akebia and other vines, hedge plants, like purple beech, *Citrus trifoliata*, and

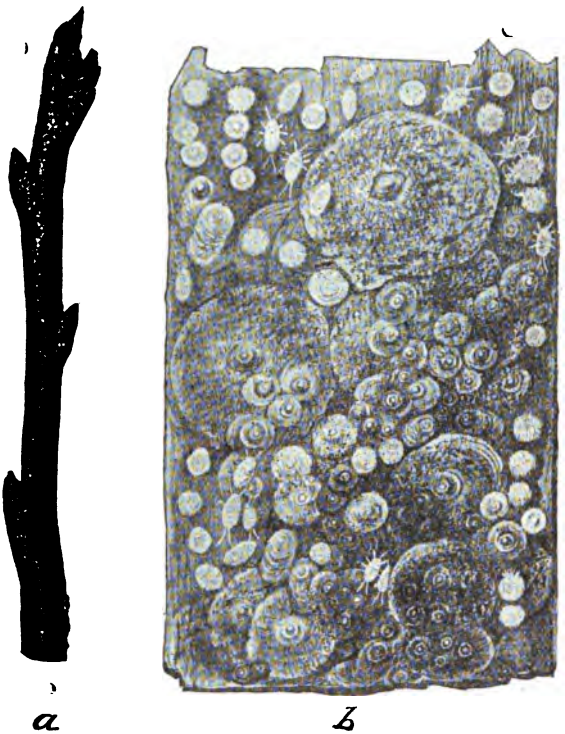

Fig. 5.
Appearance of the scale on bark: *a*, infested twig, natural size; *b*, bark as it appears under a hand lens, showing scales in various stages of development, and young larvæ. (From Div. Ent., U. S. Dep't Agriculture.)

Japanese quince, occur everywhere, and form an ideal home for the San José scales that are scattered everywhere through the entire district.

This general distribution of the scale is a *fact*, and not mere inference. I have seen it in or received it from almost every town between the points above mentioned, and as here gardens join closely, there is nothing to hinder unlimited spread. A similar state of affairs exists

on Jersey City Heights, where the sparrows have spread the scale everywhere.

A realization of this fact is important, as it disposes at once of all suggestions as to the possibility of extermination. The scale will set on almost anything, and will maintain itself for a time even on herbaceous plants. Professor Johnson, of the Maryland Station, has seen it in all stages on milkweed, and it would be shorter now to make a list showing what is not attacked than an enumeration of such as are likely to furnish food for this pernicious pest. The issue in this State must be squarely faced; the San José scale is thoroughly established and must be dealt with as a native species. Whether it will continue to be the serious pest that it undoubtedly is at present, is quite another question.

The scale is a menace to fruit culture, certainly, provided we let it alone; but if it be steadily fought, it will assuredly be conquered. The farmer must fight the battle for fruit against one additional enemy, but it is by no means proved as yet that he will not gain some assistance from nature. Its parasites are increasing enormously, it is not exempt from disease, and it is seriously handicapped by its inability to travel except in the larval stage.

Introduced Lady-Birds.

Nothing has been seen in 1897 of the Californian Coccinellids introduced in 1896. Most of the places in New Jersey in which they were introduced were searched by myself on several occasions, but not a sign of the species has been noticed. This is in accordance with what was expected, because the climatic differences are too greatly marked.

Concerning some of the lady-birds mentioned in my report for 1896, Mr. John Scott, Commissioner for Los Angeles county, California, wrote March 31st, 1897: "Since you were here the *Orcus chalybeus* has almost entirely disappeared and only a stray specimen is to be found. The *Rhizobius ventralis* is to be found in considerable numbers between Los Angeles and the coast, but it does not clean up the black scale. In the interior, along the foothills, it is a complete failure so far. Last summer and autumn I put thousands in some grape fruit trees on my place at Duarte that were badly infested. The scale has increased greatly in numbers and not a single parasite to be

found. The twice-stabbed is still in my opinion the best (after *Vedalia cardinalis*) of all the lady-birds."

The following letter from Mr. S. A. Pease, on the same subject, will explain itself, and is in accord with my conclusions in the report for 1896:

"SAN BERNARDINO, Cal., Oct. 27th, 1897.

"The *Rhizobius ventralis* have literally accomplished nothing, and are not to be found in any numbers in San Bernardino county to-day. John Scott reported them in great numbers in Los Angeles, January 7th, 1897.

"I have a letter from him, dated Duarte, September 16th, 1897, in which he says: 'We are fumigating the whole of Duarte for black scale. * * * I never had so much black scale as this year. I have put thousands of *R. ventralis* in my trees during the last three years, but can find no trace of them.' In 1896, I placed in month of June 10,000 *R. ventralis;* June 11th, 5,000, and June 25th, 5,000. These were distributed in twelve orchards, and placed each time in same trees. They raised the price on *Rhizobius* next month, so I only used 3,000 twice, same trees as before, during July, August, September and October.

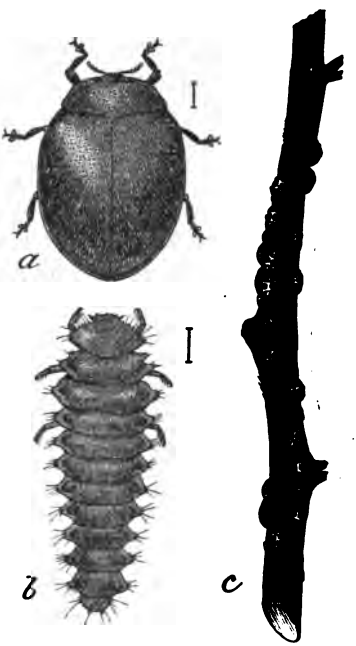

Fig. 6.

Rhizobius ventralis: a, larva; *b*, beetle; both greatly enlarged; *c*, a twig infested by black scale, natural size. (From Div. Ent, U. S. Dep't Agriculture.)

"To-day I cannot say that I think we were benefited by them. We have been fumigating in Ontario for nearly two months, and shall continue for some time yet with 120 tents of different sizes. Will probably use seven or eight tons of cyanide of potash during the season, for which we pay thirty-one cents per pound; sulphuric acid, double that amount, at two and three-quarters cents per pound (avoirdupois). Mr. Craw lamented that we were going to fumigate; desired us to still use the lady-birds. I purchased our *R. ventralis* of E. W. Harrold, whose

orchard is near Santa Paula. This season Mr. T. C. Teague, who represents eighty acres of citrus orchards in the same locality, purchased an outfit of tents and said he would fumigate.

"The Santa Barbara Lemon Exchange wrote me for directions to fumigate, and said Professor T. N. Snow would ask their Supervisors for tents to fumigate. I sent the desired directions, but asked 'how about *Rhizobius?*' They answered that they could not rely upon them, as one orchard that had been infested with black scale would be clean and another orchard, two hundred yards from it, would remain dirty. I think this very poor encouragement to continue to rely upon the Rhizobiids. We are fumigating systematically, *i. e.*, in large blocks, leaving no infested orchards mingled in to re-infest those disinfested."

A somewhat better report comes from San Joeé, where the *Rhizobius* is said to have cleaned up some orchards completely.

While *Rhizobius lophanthæ,* which was introduced into New Jersey, is much more hardy than *ventralis* and has shown itself able to spread naturally, it is probable that the change was too great for them, the unaccustomed moisture being quite as likely to prove fatal as an actual difference in temperature.

Yet this line of experiment has not been entirely abandoned. Professor T. D. A. Cockerell is convinced that the home of the pernicious scale is in Japan, notwithstanding the fact that it has never been found there by collectors, in any numbers. While the arguments in favor of Japan are not convincing they are at least plausible, and I wrote to several persons interested in entomology in Japan, asking them to obtain specimens of certain scale-feeding lady-birds for importation into New Jersey. An arrangement was actually made with Professor M. Matsumura, of the Sapporo Agricultural College, but no specimens were received.

The Nursery Problem.

Up to the present time the spread of the pernicious scale has been due almost entirely to nurseries. During 1896 one instance of natural spread was brought to my attention, in 1897 two such cases occurred and probably others have not yet been discovered. Nevertheless, nurseries are chiefly responsible, though not all infestation in New Jersey is due to our own nurseries. In two instances, at least, the infested stock was purchased from New York State nurseries, but where it was grown is by no means clear, for the nurseries from which

the purchases were made seem to be free from the scale at present. So far as I am aware there are five infested nurseries in our State—the Pomona nurseries at Parry, the Lovett nurseries at Little Silver, a small establishment with little fruit stock in Hammonton, and two nurseries with a local trade, at Mount Holly. The latter have never sent infested stock out of the State, so far as I am aware, but have aided the Pomona nurseries in spreading the insect throughout Burlington county.

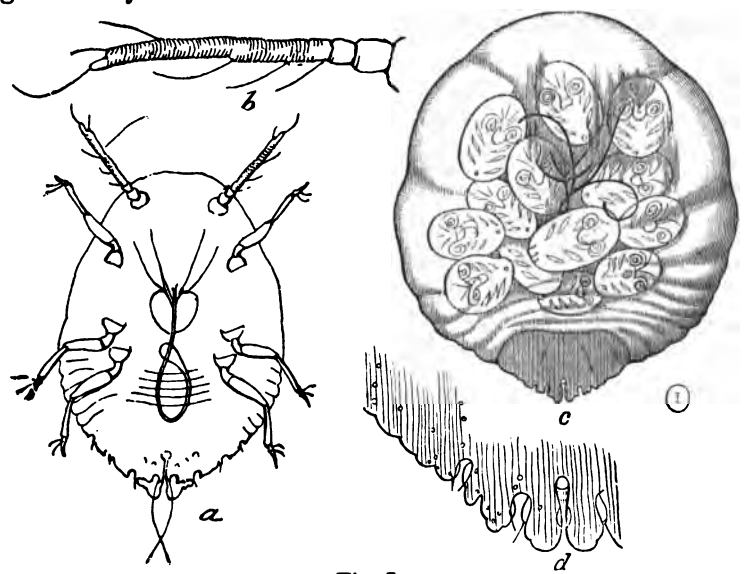

Fig. 7.

a, larva of the pernicious scale, very much enlarged; *b*, its antenna, yet more magnified: *c*, the female, showing young through the body wall; *d*, outline of anal-plate of female. (From Div. Ent., U. S. Dep't Agriculture.)

I am informed that the Rogers Nursery Company, of Moorestown, has sent infested stock out of the State; but this was stock not grown by them, and the nursery has since then ceased to exist. According to the most reliable information obtainable by me, infested nurseries exist in several States to the north, west and south of New Jersey, and purchasers of stock should make certain in all cases that what they receive is actually clean and free from this insect.

So far as home-grown stock is concerned, I have found no scale present in the nurseries of Charles Black and Joseph H. Black, Son & Company, at Hightstown; David Baird, Baird P. O.; Flemer & Felmly, Springfield; Hiram T. Jones, Elizabeth; Stanton B. Cole,

Bridgeton. Stock grown on any of these nurseries I believe to be free from the San José scale; but that does not mean that everything they send out during the season will be equally clean. All nurserymen list many plants and trees that they do not grow. In some cases it is grown for them where it can be produced cheaper, and in many others they purchase wherever they can obtain what is wanted. This method of securing stock seems to be absolutely necessary, and is really an advantage to the purchaser in most cases, since the stock thus obtained is more likely to be healthy and true to name.

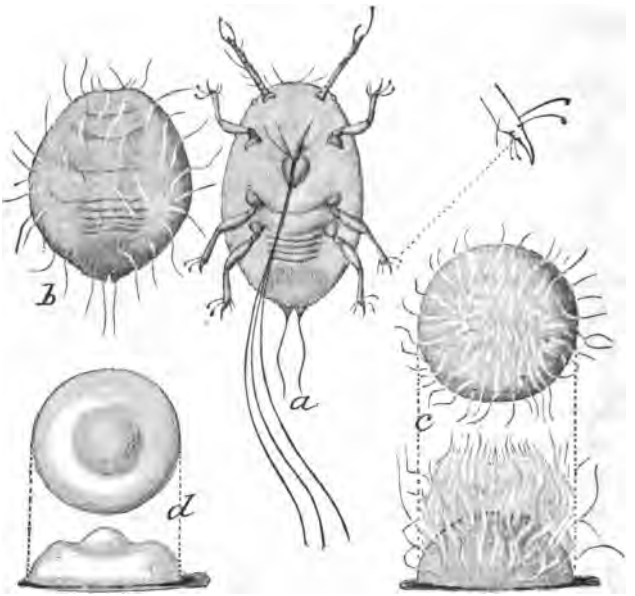

Fig. 8.

Young larva and developing scale: *a*, ventral view of larva, showing sucking beak with the bristles separated; *b*, dorsal view of same, somewhat contracted, with first waxy filaments appearing; *c*, dorsal and lateral views of same, still more contracted, illustrating further development of wax secretion; *d*, later stage of same, showing matting of the waxy filaments and the first form of the young scale—all greatly enlarged. (From Div. Ent., U. S. Department Agriculture.)

The disadvantage is in the impossibility of stating the actual condition of all the stock distributed, so far as infestation by insects or disease is concerned. For this reason I urge upon the purchaser the importance of close examination of all stock received, and also, if the dealer claims that his grounds are free from scale, that he insist on a positive statement that the stock purchased was actually grown on that uninfested land.

The utmost care should be taken to prevent the inroduction of the scale into localities as yet free from it, that the spread of the species will be at least greatly retarded.

"Certificates."

One of the first results of the discovery of the San Joeé scale in Maryland was the passage of a law denying admission into the State to all nursery stock which was not accompanied by a certificate that it was free from San Joeé scale, peach yellows, rosette or other dangerously injurious insects or plant diseases.

Nurserymen with a trade in Maryland were compelled to secure such certificates to enable them to fill their orders, and usually a copy was printed in the catalogue. Entomologists generally advised their constituents not to purchase without a certificate, even where none was legally required, and the result was that nurserymen throughout the country were anxious to secure such documents.

In New Jersey there is no State officer upon whom the duty of giving such certificates could be imposed, and application was made to the Experiment Station for assistance.

It is clearly no part of the duty of the Entomologist of the Experiment Station to examine nursery stock for the benefit of its owner, and to enable him to sell it in other States. Such work is in no way to the advantage of the State at large. Nevertheless, after consultation with the Director, I decided to make such examinations as were asked for, and to give such certificates as were proper, because there was no one else to do it, and our nurserymen would be placed at a disadvantage if I denied them. It was deemed desirable also to learn from actual examination how far our nurseries were real sources of danger.

It was, therefore, as a matter of favor that the examinations were made, and the nurserymen were asked to pay actual traveling and other expenses, but no fee or other charge was asked for or received. It was impossible for me, as it is for anyone, to say positively that the examined stock was free from the plant diseases mentioned in the Maryland law; hence the statement was substituted that no *indication* of such troubles was found. The character of these certificates is best understood by the following copy:

"This is to certify that I have this 9th day of October, 1897, examined the nursery stock on the Village nurseries, Jos. H. Black,

Son & Co., proprietors, grown at Hightstown, Mercer county, New Jersey, and found no indication of the presence of the San José scale, peach rosette, yellows or any other dangerous insects or plant diseases that might be transferred on nursery stock from the nursery to the orchard.

"This certificate covers only stock that is grown on the grounds above mentioned, and is valid during the shipping season of the fall of 1897 and spring of 1898.

"(Signed) JOHN B. SMITH,
"Entomologist."

The weak point in this system is that there is no way to control the use of the certificate. An unscrupulous nurseryman may make it cover everything he sends out, whatever the source of the stock, and in one case at least this was actually done.

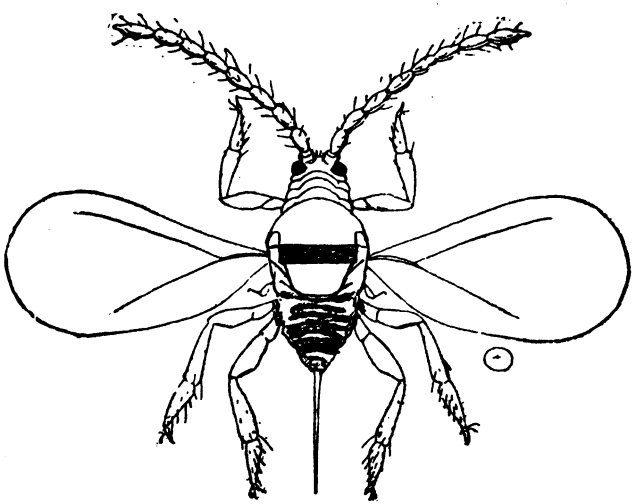

Fig. 9.
Male of the San José Scale. (From Div. Ent., U. S. Dep't Agriculture.)

To exercise any real control over shipments made would require more time than I could possibly devote to the subject, and would benefit no one except the nurserymen. Without some supervision, the certificates are liable to be misused, and this would tend to discredit the honesty or efficiency of the person signing it. For these reasons it has been decided to give no more certificates under present

conditions, and all those affected have been notified in season to admit of an application to the Legislature in 1898 for such relief as seems necessary.

How the Scale Spreads.

Reference to previous reports and bulletins will show that only in the larval stage is the scale capable of spreading. The larvæ are quite active, but show no disposition to make long journeys. They get along readily enough on a smooth surface, but are helpless on rough or powdery land, tending to bury themselves in the soil rather than to crawl over it. In most instances, they do not get over six inches from their hatching-point, provided they have a chance to set and are not carried away. The males seem to travel farther than the females in the larval stage.

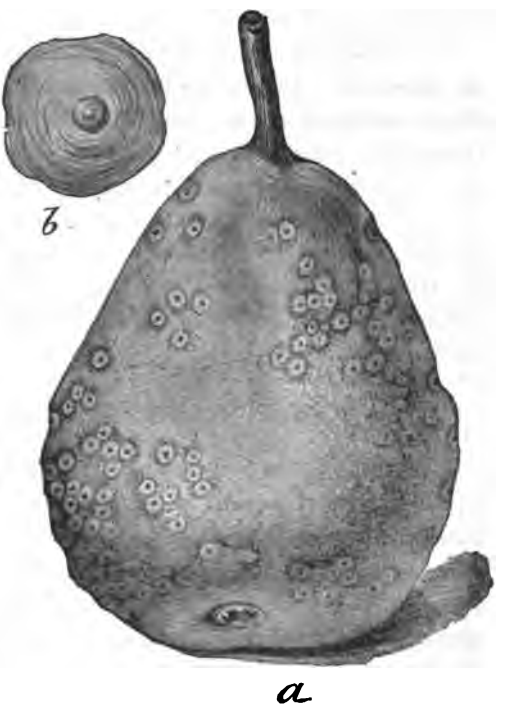

Fig. 10.

a, Bartlett pear infested by scales, natural size; *b*, a single scale, enlarged. (From Div. Ent. U. S. Dep't Agriculture.)

Of artificial agencies, the wind is important for near-by spread. Where trees are badly infested the young jar off readily, and the clothing of those walking beneath them has been found peppered with larvæ, as have also the herbaceous plants beneath and between the trees. The case of infested orchards where the spread is quite regular from a central point are also examples of probable wind spread. Many of those blown to the ground may reach there sufficiently close to another tree to enable them to get upon it. I believe that this is at least as often the case as for a larva to be blown from one tree into another.

Insects come next for local distribution, and at least as important as any are the lady-birds. I have seen *Pentilia misella* covered with larvæ, and have several times noted *Chilocorus bivulnerus* with specimens on the elytra. Ants have been found carrying them, and this may in some cases explain the infestation of small or isolated shoots or trees which are easy of access to ants, but impossible for scale larvæ.

Birds are unquestionably the agents for wider distribution, and three cases have come under my observation where they only could have carried the scales.

The important feature is that the scale left to itself has little power of spreading. I have known it to kill a tree and die with its food plant, because not a specimen could get to the next tree, which was twenty feet away. Spread by birds or similar agents becomes probable only when larvæ are very abundant; hence if the insect could be kept down easily it would not amount to very much even in years. If the nursery danger could be eliminated, a decade might be required for the scale to spread over a single county. In fact, even with nursery distribution for nearly ten years, Burlington county is not yet uniformly infested.

Observations and Experiments in 1897.

It was noted last year and previously that the scale did not thrive on the red shale or north of the line extending obliquely from Trenton, northeast to about Woodbridge, near the Atlantic coast. A glance at the geological map of New Jersey shows this line clearly, and shows also that it is broken near the coast, where there is an area of post-tertiary alluvium extending west of the Palisades as far north as Hackensack. This includes Jersey City, where the scale has been found in town gardens.

That this northern section has received the scale is certain, because I have actually obtained specimens and know of infested trees set out. Yet at the present time I do not know of even a single infested orchard—no proof, of course, that none exists; but it offers a fair presumption. I have seen scaly trees at Washington, in Warren county, received from a Southern nursery; but most of the scales were dead, and the nurseryman who handled them informs me that all have been replaced by sound stock and the infested plants destroyed.

I have received infested twigs from Morristown, Morris county, and one sample from New Germantown, Hunterdon county. In all cases these were isolated trees with few scales, most of which were dead and on which no young or recent sets were observed. Later inquiries resulted in the report that the insects seemed to be disappearing—an impossible one where the San Joœé scale flourishes. A few scaly trees were found in New Brunswick gardens, but were destroyed before I had any opportunity to make observations.

Between New Brunswick and Riverton, while there is little difference in temperature, there is much in the physical character of the soil—shale in the first instance, light sandy loam predominating in the other. The most obvious experiment was, therefore, to test the question whether the red shale in itself prevented the growth of the scale.

Red Shale.

A barrel of red shale was shipped to the Messrs. Parry in April, and on the 26th infested species of various kinds had been planted on it. The barrel had been cut in two and each half was sunk into the soil and filled with the shale.

June 14th found the larvæ attacking the seedlings which had been put in to test the question whether a plant fed on shale only would support the insects.

June 18th I found on all the young trees living scales and crawling larvæ.

August 27th the plants on the red shale are as badly infested as any could possibly be. The experiment was called a failure and discontinued.

Theoretically, this experiment promised little, but there was a bare chance and I tested it. Plants were taken from the nursery rows and set in the shale, and seeds were put in the shale to produce plants grown in no other medium. The scales flourished as well in all respects as on those grown in the nursery soil.

Sulphate of Iron.

It has been claimed that trees supplied with an abundance of iron in soluble form were more resistant, or less to the taste of sucking insects than others. One of the obvious chemical differences between the red shale and the lighter soils of Burlington county is the presence of

more iron in the former, and assuming that perhaps this might in some way exercise an unfavorable effect on the scale, I requested Mr. Horace Roberts, at Fellowship, and Mr. Howard G. Taylor, at Riverton, to use fifty pounds of sulphate of iron per acre on a part of their infested orchards. I also requested the Messrs. Parry to water some infested plants at regular intervals with one ounce sulphate of iron dissolved in one gallon of water.

June 18th, at Parry, found the plot watered weekly with the sulphate of iron solution at least as lively as any other, and crawling larvæ everywhere.

July 14th was unable to note the slightest difference between the experiment plants and the others in the vicinity. All are swarming with larvæ.

August 27th nothing advantageous was noted, and the experiment was called a failure.

In March Mr. Horace Roberts used one hundred pounds of sulphate of iron over two acres of orchard. July 7th I could see absolutely no difference in favor of these two acres. September 26th another examination was made and no difference could be seen. Everything was very thoroughly infested.

Mr. Howard G. Taylor wrote concerning his experiment, April 29th: "I did apply, as requested, fifty pounds to about half an acre of Keiffer trees three weeks ago, and I had it well worked into the soil with a harrow."

June 16th he wrote: "I can see no special difference between the trees treated with sulphate of iron and those not treated."

I visited this orchard several times during the season and did not see, up to September 26th, any difference in favor of the treated trees. This orchard is now in very good condition, however, and differences would not be easily noted.

The results seem fairly conclusive. The sulphate of iron was given the most advantageous conditions in the experiment at Parry, and the scales thrived on young stock fed with it in solution every week until the experiment was given up.

The applications on the Roberts and Taylor orchards were on a sufficient scale to test the commercial feasibility of the material. Two acres on the Roberts farm, using 50 pounds an acre, showed absolutely no effect. Fifty pounds on half an acre, or double the quantity used in the other experiment, was equally ineffective.

Hydraulic Cement.

This is not an insecticide in any true sense, but there was a chance that it might either prevent the scales covered by it from breeding or others from setting. Therefore, early in the season three young trees were treated at Parry with cement and skim milk to test the matter.

June 18th I found that in two cases the application had been quite thin, and the old scales had broken the crust so that the young were able to get out from beneath it. Sometimes the scales had been so much lifted that they dropped off, leaving the insect exposed and unprotected. In such cases only the young that were born at the time this happened survived.

The third tree had been much better covered, and no moving scales were observed. The tree was as badly infested as any, but at that time the young shoots were doing well, and the body of the tree was still covered with the cement, through which no scale had been able to break.

August 27th I found this tree with the coating in almost perfect condition, and the cement had prevented the setting of any scales on the main stem. Some old scales broke the cement and dropped off early in their career, and it seems that almost all the young that attempted to set failed. At all events, there was not a live scale on the cement-covered trunk, and only a few specimens were found on the twigs. The tree had not in any way suffered from the application.

September 26th the tree was again examined and more scales were found on the young shoots; while wherever an old one had dropped off early in the season, leaving an unprotected spot, a dense group of young was now set. No case of setting *through* the cement was noted. The tree was hardly half an inch in diameter, and the cement had probably hampered its growth a little. Nevertheless its shoots were healthy and the scale attack of the previous year may be responsible for its stunted appearance.

The test was not quite a fair one for the cement, which may under certain conditions prove of use. On a larger tree with a thicker coating, the scale could not have forced the cement layer, particularly if the application had been made just before the date of reproduction when the strain of a gradual growth was eliminated. Or a very early application might seal up the males and would prevent the fertilization of the females.

No larvæ can set through this cement coating, hence trunks can be protected at least to the branches, and the tree shielded from a drain which in young stock is very serious. Of course a material of this kind must prove most satisfactory on smooth trees, where there is no difficulty in making a complete coating. On rough-barked trees great care would be required to do effective work.

Whale-oil Soap.

This has given much the most satisfactory results in the past, and a great deal was used during the winter of 1896–97. No experimental applications were made by me, since the best test of the value of an insecticide is its effectiveness in actual field work. It may be well, however, to say first, that up to October, 1897, not the slightest trace of San José scale was observed on any of the trees treated by Mr. G. W. Jessup and myself during the winter of 1895–96. There have been two full breeding seasons since the application was made, and had there been any surviving scales they would have shown some signs of their presence by this time.

The material used was the Leggett Anchor brand whale-oil soap, and the application was made with a brush on a bitter-cold day, when the mixture froze to the tree as fast as it was put on. Two pounds were used in one gallon of water, and there is no question as to the thoroughness of the application. Whether the fact that the mixture froze to the surface had anything to do with the result, I cannot say; but it is more to the point that there was a considerable period of clear, dry weather immediately afterward.

During 1896 I found the premises of Mr. Thomas Wilson, at Port Monmouth, pretty well infested by the San José scale. Plums were especially covered, but apple, pear and even grapes were also attacked, and a serious condition of affairs existed. So I notified Mr. Wilson and advised him to cut back the plums, which were of good size and in bearing, almost to the trunk, and treat them with whale-oil soap.

July 1st, 1897, I found all the plum trees severely cut back and, according to Mr. Wilson, they had been twice treated with the soap mixture, two pounds in one gallon of water. The trees were sending out luxuriant sprouts, and after the closest search I failed to discover any trace of living scale. There were no larvæ, no recently-set scales, and no trace of life anywhere. It is quite possible, of course, that

some young may have hatched and crawled into the foliage where I could not see them; but as all the old scales were on the trunk, any larvæ then hatching from them would have been easily visible.

On the pear trees I did find living scales. These had not been cut back at all, and had received only one or no treatment.

September 30th Mr. Wilson wrote that he was not then able to find any trace of live scales on his plums; but he sent twigs of Bartlett and Lawrence pear and crab-apple on which there was plenty of living scale.

It is, of course, unsafe to say that the scales were entirely destroyed on the plum trees, but they were so greatly reduced that it will be at least midsummer of 1898 before the fact can be established that any survived. The trees would not stand many similar treatments, of course, if they are to be of any use for commercial purposes.

Just outside of Riverton is the orchard of the late Mr. Edward Lippincott, in which several colonies of Californian lady-birds were liberated in 1896. Mr. Lippincott was in the habit of washing his trees with potash during the winter and whitewashing the trunks during the early summer, and undoubtedly he checked the spread of the scale, unconsciously, for several years. In 1896 it had become serious, however, and had spread all over the trees, rendering some of the fruit unsalable, therefore it was determined to treat thoroughly during the winter of 1896–97.

One application was made of some mixture of lime and soap, but this was not well applied except on the trunk and larger branches, and on June 12th I found an abundance of living scales, though breeding had scarcely begun. Later the inefficiency of the application became more marked, and the trees in early September were in almost as bad a condition as at the same period the year before.

One of the first points in the State where the whale-oil soap was used was on the Richardson place at Mount Holly. Their trees were badly infested when received and came from outside New Jersey. Numerous trees had been treated here, but until September of this year I was never on the place. September 28th I was near by and visited one of the orchards which had an attack of "blight" that was much more destructive than the San José scale. But evidences of the latter were sufficiently apparent. Many of the trees had the bark of the trunks and branches scarred and wrinkled in a manner easily recognized by one familiar with the work of the scale, and it did not

need Mr. Richardson's assurance that the trees had been once so completely coated that no bark was visible. Lawrence and Bartletts had been worst infested, and some trees were so badly injured that they were taken out. A number of larvæ were observed crawling about, but the infestation was a slight one, comparatively, and represented the progeny of a very few missed scales. I was informed that the fruit from several acres of previously-infested trees came in this fall with scarcely a trace of scale. The orchard is not clear by any means, but it is no longer a source of danger, and if the "blight" leaves any considerable portion of it the scales will in time be worked out completely if summer treatment is applied to supplement the highly effective winter work. All the soap used here was made by the owners according to the formula published in previous reports.

Perhaps the largest and worst-infested orchard in the State is at Fellowship, where a number of experiments were made. The orchard was planted on stump land as soon as the trees had been cut down; apple, pear, peach, plum and cherry being closely set and so arranged that peaches could be brought into bearing for a short period before the slower-growing trees really needed the ground. In such a rough territory the scales found ideal conditions, and no serious attempt was made to check them until the winter of 1896–97, although treatment had been made during 1895–96. Just what was done is best shown by a letter from Mr. Horace Roberts, dated June 9th, 1897.

"In the early winter I treated my infested orchard with a weak solution of whale-oil soap. The ground was so covered with stumps that the work was not very thoroughly done. After clearing the land of stumps we sprayed carefully with whale-oil soap in March. It did not kill all the scales, but it took off the greater part of them. Trees that were almost smothered with the scale before I treated them look now as if they would develop a crop of fruit. The young scales are now developing again, and unless the trees are treated with something this summer I believe that by fall they will be as badly infested as ever."

July 7th my note on a visit to the orchard was: "Found that the washing of the trees had been of comparatively little use. The trunks had been well cleared and the bark was in fine condition, but the branches had not been cleared and the result is plenty of scales from the crawling young to the half-grown condition. The peach trees which had been especially well treated are as bad as any others; they

will probably ripen their fruit and then die. No scales are upon peaches, but upon apples and pears the damage promises to be considerable."

September 26th, no summer treatment having been made, found Mr. Roberts' fears confirmed, and his trees as badly infested as ever, yet in sound condition and flourishing, for they had been abundantly supplied with food and had matured crops. Peaches had suffered most, and many branches were dead as the result of the scale attack. Many of these trees will be taken out, and the ground will be left in a better condition for work among the other fruits.

This case shows the wonderful reproductive powers of the scale, for with a small percentage of survivors it recovered in one season all the ground lost by the winter treatment, and is probably even more numerous than before. It also illustrates the fact that, unchecked, peach trees attacked by the scale live no longer than three years.

This is the fruit most severely injured and the tree dies from the top, sending out water sprouts from the trunk as the branches die and thus in some ways counterfeiting yellows.

Apple and pear are much more resistant, but the scales seem to retard the maturity of the pear fruits somewhat.

There are several points of infestation near Egg Harbor City, in Atlantic county, principally toward Cologne (Germania) and Pomona. Almost all of these are on young trees and somewhat isolated. Perhaps the most extensive case is that of Mr. Henry Pfeiffer, near Cologne, where whale-oil soap of his own manufacture was used early this spring.

June 25th I looked over some of these treated trees—apple, pear, and plum. On some of the trees there was little sign of scale discoverable, and on a few not a young set scale nor crawling larva could be discovered. On most of them, however, there were some newly-set scales and occasionally a tree was pretty well peppered. In no cases had the young scales on treated trees gotten on the fruit. On a few untreated pear trees the contrast was striking: every pear was covered with scales, sometimes so closely that it was almost impossible to see the surface of the fruit. On many of the treated trees the scales now present are sufficient to recoat them completely if they are left undisturbed during the summer.

An interesting feature is the time at which some of these trees were treated. A beginning was not made until late, and some of the trees

started and even blossomed before all were sprayed. Some were then left untreated, and some that were so badly infested that they could not be left were sprayed after they had come out in full bloom. Next day leaves and blossoms were black, and all hope of fruit was abandoned, quite without cause, for when I saw these trees in late June they were loaded with fruit, the foliage was good and there was, if anything, less scale than elsewhere.

The Howard G. Taylor orchard, near Riverton, at first consisted of peach and Keiffer pear trees, and it was so badly infested in 1896 that Mr. Taylor was almost ready to take it all out. Indeed, most of the peach trees were taken up and burnt; but at my request he left the pear trees. There are between 400 and 500 trees now in the block which was allowed to become so badly infested because it was believed three years ago that the Keiffer was almost or quite exempt from scale attack.

During the winter of 1895–96 caustic potash dissolved in water was applied with unsatisfactory results, and in 1896–97 the Good potash soap, two pounds in one gallon of water, was used on all save a few trees which were subjects of other experiments.

All applications were made after January 1st, 1897, and some in February. The trees were first painted with the soap as far as this could be thoroughly done and then the tops were sprayed; an average of a gallon of the mixture, costing seven cents, being used on each tree.

April 29th Mr. Taylor wrote: "I can find but very few scales on the trees having soap on them that look alive."

June 12th I looked over many of these trees carefully and it was almost impossible to find any trace of living scales. It seemed as if the application had been absolutely successful, but with so much material a single field examination could not be considered final. Two trees had been left as subjects for experiments with the fungous disease, and these were fairly yellow with young larvæ, or white with newly-set scales. On all sides of these trees were others which last year were equally infested, but on them there was not a single larva or newly-set scale to be seen. The contrast was almost startling as indicating the multitudes that had been destroyed by the treatment.

June 26th Mr. Taylor wrote: "Can see a few young scales on a good many trees to-day, but they are fairly swarming on the two trees having the Florida fungus tied on. I never saw so many at one time."

Fig. 11.

Fumigating *Citrus* Trees in California. (From the Year Book U. S. Dept. Agriculture, 1896.)

It may be in place to say here that this orchard was loaded this spring with bloom enough to have broken down every tree with fruit, but a frost occurring just after the blossoms opened resulted in reducing the set to a light and very irregular crop.

The records of the New Jersey Weather Bureau show that on the 20th and 21st of April the minimum temperature at the Stations nearest to Riverton was 26° at Moorestown and 25° at Beverly. These were killing frosts and the light crop in this orchard is not chargeable, therefore, to anything used as an insecticide. Mr. Taylor himself speaks positively on this point, and says his orchard would have been overloaded but for the frost.

June 23d I found little change from the 12th. On some trees a few young scales were observed, but most of them were yet entirely clear. There were, however, a number of scurfy scales just setting, and these had led Mr. Taylor to believe in a more general distribution of the pernicious scale than was actually present. The soap application which was so effective against the San José did not injure the scurfy scale, which was then in the egg state. The trees looked vigorous and in much better condition than at any time for two years past.

July 15th examined quite a number of the trees without finding traces of living scale, old or young; but in the majority of instances it was evident that a few scales survived and were breeding. Except on the check trees, which I asked Mr. Taylor to spray with kerosene, there were not specimens enough to make it necessary to treat the trees. All the fruit was without trace of scale except on the check trees, where it is badly spotted.

August 7th matters were much as before. There has been a great deal of rain, and the scales are breeding slowly.

The orchard was again visited September 12th and 25th, and the results were yet satisfactory. Some of the trees seem to be entirely free from scales, but the majority have a light peppering. This is a very satisfactory showing when the reproductive powers of the scale are considered.

October 28th, 1897, Mr. Taylor wrote: "Am very thankful to be able to report a great improvement in my pear orchard over a year ago at this time. When gathering the pears a few weeks ago, I took especial care to look for scale, and found comparatively few trees showing any signs of them, very little of the fruit being marked, and that

not badly. These trees I marked, and now propose to use oil (common headlight) on them this winter. The trees that received the second dose of oil do not look as well as the other, untreated trees, but I could see no living scale when I last examined them.

"As to the effectiveness of the two treatments, I think we shall have to consider the oil as having done the best. The cost of the two being nearly equal, the oil is the least trouble, but I am not yet ready to admit that it is the best for the tree, as I fear the buds are somewhat injured by it, while I could see no injury from the whale-oil soap. I would not advise oil on young wood on plum trees, as two of mine have not recovered from the dose given in May or June to kill the green lice. If whale-oil soap is thoroughly applied, I think it very effective; but it will not spread as readily as coal oil, and we are more liable to miss some parts of the tree. With the ordinary nozzle (and poor old hose) we use more oil than I think we ought. Before spraying I hope to secure a finer Vermorel nozzle."

Mr. Taylor compares the summer kerosene-treated trees with the winter soap-treated trees, which is not quite fair.

In September it was discovered that the extensive orchards of Mr. Granville W. Leeds, near Rancocas, contained examples of San José scale, and on the 16th I found nearly all his peach and many of his pear trees infested. The peach trees have been out three years, have borne a crop this year, and are in excellent condition. It would be difficult to discover a finer orchard in the State, and there was no suspicion that the scale was present until it was seen on some pear fruit. I found that the infestation on the pear probably came from the peaches, which must have been scaly when set out. A young orchard covering eight acres, set out in the spring of 1897, had most of the trees infested, and many of them badly peppered. All the trees came from the same nursery.

The reason why the old peach trees are yet in such good condition is that Mr. Leeds washes his trees each year with a whale-oil soap, lime and carbolic acid wash. There is no doubt that this kept down the scales while the trees were small and the trunk was chiefly infested; but now they are scattered throughout the trees, and more active measures are needed. This case is cited only to show that, even where not directly pointed at the insects, a soap-wash may yet be very effective in retarding injury.

A great deal of fish-oil soap was used this year in the Parry orch-

ards, and perhaps this is a good place to say that this center, from which so much scaly stock has been unwittingly distributed, is now in much better condition than at any time since the existence of the scale was recognized. At the beginning, several infested blocks, containing thousands of the most valuable varieties, were uprooted and burnt. Hundreds of fruiting trees were taken out and made into firewood, and many others were cut back and thoroughly treated.

Practically no fruit stock has been planted on the home ground for two years past, and what remains is being carefully looked after. A satisfactory fumigating apparatus has been prepared, in which all stock is treated with hydrocyanic acid gas before it is sent out.

Treatment with whale-oil soap was continued all winter; everything suspected being thoroughly drenched, and the work ran over into the spring after the plants had started. There was no attempt to keep records except in the case of unusual treatments, hence general results only can be stated.

One case deserves special mention. It was discovered in the early spring that a row of overgrown Japan golden russet pears were rather badly infested with scales. The plants were full of foliage when the discovery was made, but the whale-oil soap was nevertheless thoroughly applied at full strength, and on that line of nearly one hundred trees, crowded in a nursery row, not a scale could be detected in September, while every stick was loaded with fruit!

Mr. Frank M. Bartram, under whose supervision all sprayings were made, could not remember the exact conditions of the fruit when the pear trees were treated, but whether or not it had already set, the treatment was certainly made when, theoretically, the plant is most susceptible to injury and the foliage most tender.

A block of walnuts, where some scale was suspected, was sprayed during the second week in May with whale-oil soap, two pounds to a gallon of water, and enough lime added to give a distinct coloring. I still saw traces of the mixture on some trees September 16th, while the plants looked perfectly healthy. No scale was discovered. Mr. Bartram informs me that the leaves were well developed when the spraying was done, and there was a good deal of blackening observable, yet all came out in good shape a few days later and absolutely no harm resulted.

June 18th, I examined the trees treated with soap once and several times, as well as some treated with kerosene, and with kerosene and

soap both. The trees were old, rough-barked and had been cut back two years ago for treatment with caustic potash in water. On all the trees treated with soap alone, living scales were found, and on those treated once only, there were crawling larvæ. Everything was backward, however, and it seemed almost as if the youngest scales only of last year's set had survived the treatment and had just attained their full growth.

August 27th the trees were again examined, and while there were many scales and larvæ, there was not nearly so much as was anticipated from previous appearances. The fruit is in good condition, and while some is quite spotted, there is no massing of specimens, such as caused crippling last year.

September 25th the trees were again looked after, and while there was plenty of living scale visible, the condition of affairs was not unsatisfactory.

Several interesting and important results appear from the above record. First, that the soap mixture of the recommended strength of two pounds in one gallon of water can be safely used much later than has been believed—plum, pear and walnut having been sprayed when in full leaf, when in blossom and with recently-set fruit.

Second. The most complete destruction of the scale was accomplished where the spraying was late. The reason is that at about this time insect growth is proceeding and in the males, perhaps, completed, the scales being, therefore, much less closely sealed at the edges and probably much thinner as well. Theoretically, the application has a much better chance of success, and practically the result seems to have been up to the theoretical requirements.

Another point is that none of the applications have been entirely effective, and in some cases seem to have been almost ineffective. On the smooth trees of the Taylor orchard the best success was obtained, and probably some trees were entirely cleared. Even a repetition of the treatment cannot be entirely relied upon in the case of old, rough-barked trees, because there are too many hiding places that cannot be reached by even the best sprays.

The success in the Jessup orchard simply emphasizes the point just made, because here were young trees, all parts of which could be brought under observation, and the application was made with a brush much more thoroughly than would be possible with a spray.

There is no doubt that whale-oil soap, whether made by Good,

Leggett, or the farmer himself, will kill the pernicious scale at any time if it be brought into complete contact with it. Practically, all the experiments establish that point. But it is equally important that we realize the fact that this complete contact with every individual scale cannot be attained under ordinary orchard conditions, and that there will remain a small residue which will increase considerably in the course of a season. The meaning of this is that summer treatment *must* be used to supplement and complete whatever winter treatment is adopted if we hope to secure "extermination."

The question of injury to fruit buds by this whale-oil soap treatment remains, but will not be considered here, further than to say that none of my experiments were directed toward this point, and the evidence from outside sources is conflicting. It seems certain that varieties differ in this as in other points, and that experience only will determine what each will stand. That late treatment will be less likely to cause injury than that made early, seems to be the conclusion indicated by the experiments recorded above and by other observers.

Kerosene.

The action of kerosene upon plant life has been previously considered and will be only incidentally referred to here.

The results of the Ohio experiment, reported by Mr. F. M. Webster, at the Buffalo meeting of the Association of Economic Entomologists, and of the New Jersey experiment, reported by me, and both given in my last report, made it very desirable that this material should be thoroughly tested, yet the convictions from teaching and previous experience were so strong that I hesitated to ask anyone to make the experiments, except on a thorough understanding that it was risking the trees.

The following letter published by Mr. Webster in his bulletin, No. 81 of the Ohio Station, will explain itself:

"NEW RICHMOND, O., September 11th, 1896.

"*F. M. Webster:*

"DEAR SIR—Yours of the 8th instant came to hand yesterday, contents noted, and in reply I wish to say that the kerosene (clear coal oil, such as we use in our lamps) which we used was applied principally in the month of February, when the ground was frozen. We applied with a small varnish brush to some small trees to the entire tree, on others only to the limbs that were the most affected.

"My brother used a barrel sprayer, applying forty gallons of pure coal oil on five hundred apple and fifteen peach trees. A part of the orchard he sprayed the second time. The applications were made respectively on the 17th and 24th days of last February—cold and frozen.

"Trees that we used the clear coal oil on two years ago, as well as those last winter, have made splendid growth, and the entire lot of trees look as though they had been rubbed smooth and varnished.

"Kerosene and a sprayer is the remedy for the San José scale.

"(Signed) D. H. NICHOLS."

To the letter published in my last report from Mr. M. H. Kelsey, the following, from a letter dated October 27th, 1897, may be added: "Now as to the use of pure kerosene. My experience has not been so conclusive that I could unreservedly recommend it. I had a Beurre d'Anjou tree—standard. When I first discovered the scale upon it the tree was badly infested. Some of the twigs had died, evidently as a result of the scale attack. I applied, as thoroughly as possible, kerosene. The tree being quite large, I cannot be sure that I reached all the scale, but am sure that all were killed that the kerosene touched. The application was made in August or early September, 1896. The tree looked well all that season, leafed out and blossomed this spring and set a quantity of fruit. In midsummer I noticed several branches were dying, and found on examination that the scale had full possession—even attacking the fruit, of which the tree carried several specimens weighing six to eight ounces each. My experience with several large peach trees has been about the same, as also with plum and cherry. After a certain stage in the scale attack has been reached, all remedies fail, large portions of the tree dying. As I stated before, on young, vigorous trees with but few scale, kerosene so far seems to be all right. I have a young Bartlett pear tree upon which I have applied kerosene, which is in good health. I made the application early last spring. From all this I infer that there is no hope of saving a tree except at an early stage in the attack, and that to be effective every scale must be destroyed.

"My neighbors have the scale in their trees, and thus, even were I to use effective remedies, it would be of little use, as the countless numbers of the pestiferous sparrows would soon repopulate my trees with scale."

The Messrs. Parry and Mr. H. G. Taylor were finally asked to risk a few infested trees, and agreed readily. The material used by Mr. Taylor was nominally 150° test, that used by the Messrs. Parry was 110°.

In the Taylor orchard, treatment was made February 17th, 1897. "The kerosene was applied with a brush, and one gallon, costing eight cents, covered seven trees used in that way."

April 29th Mr. Taylor wrote: "I see no difference in the growth of the trees treated with oil from those treated with soap; not quite so much bloom, perhaps, though a large part of the germs are black over the whole orchard from the cold of last week."

June 12th, when I examined all the trees treated with kerosene, I found them in all respects equal to any others in the orchard, and failed to find a living scale in any stage.

June 23d on the kerosene-treated trees not a living scale in any stage was found, while on many of the soap-treated trees signs of live scale were discovered. The kerosene has also cleared out the scurfy scales, in strong contrast to the trees treated with the soap, on which these scales were setting thickly.

July 15th yet failed to discover a single live scale in any stage on fruit, foliage or other part of the trees. Thereafter, for convenience, my examinations were confined to the largest trees at the end of one of the rows, and the notes refer to these two trees only.

August 7th showed no sign of living scale in any stage.

September 15th no living scales in any stage were noticed on the fruit, and none were found on either trunk or branches.

September 25th a few specimens were seen for the first time on the fruit; but no young or larvæ were seen on trunk or branches.

Here was a single treatment clearing badly-infested trees so completely that not until late September was it possible to detect a trace of the scale. It is not even certain that the scales found at that time were really born there, for the weak point in the experiment is that the kerosene-treated trees were surrounded by others on which considerable scale developed before any was noticed on the kerosene examples.

July 15th the two trees which had been left to give the Florida fungus a chance had become so horribly infested that it was deemed unsafe to leave them longer untreated. Larvæ were literally swarming and showed up in sharp contrast to the new white scales which

almost touched at this time. It seemed scarcely possible that what was then moving about could find room to set, and I have no doubt that some of the scales afterward found on treated trees near by really came from here.

I therefore asked Mr. Taylor to use undiluted kerosene as soon as possible, and he wrote August 1st: * * * "I did, however, give the trees a good spraying July 23d, about 2 P. M., and bright sunshine at that time, but by 4 P. M. we had a heavy shower, or rather several, with high wind and a little gale, but I think it killed a great many, if not all, the scales. I used about one gallon on the two trees with a Vermorel nozzle."

August 7th I examined the trees. One had not been well covered because of the high wind, which made it impossible to reach the top of the shoots. The second tree got the benefit of this and was thoroughly done, while a third was almost as well done as the others from the flying mist.

On the first tree a few live scales were found at the tips of the twigs. On the second tree not a sign of live scale was visible. The uncounted thousands that had been swarming there three weeks before had been wiped out completely by the single application. Carried off one of the fruits from this tree for examination and left the others for future developments.

August 9th examined the pear from the sprayed tree, and of the estimated 450 to 500 scales on this single fruit, not even one appeared to be alive. Every scale was turned, and particular attention was paid to the insects in the calyx end, as that would be least likely to be hit by an ordinary spraying. In no case was there even a doubt of the death of the insects.

To test the killing power of kerosene, I brought in a large Duchesse pear, the surface of which was densely set with scales, especially at the calyx end, where the skin was entirely invisible. All stages were represented, from crawling larvæ to the breeding females. The pear being held upright, kerosene in drops was applied at the stem end and allowed to spread over the surface. The object was to test the spreading power, and drops were added until the oil had reached everywhere. The pear was then set in the sun in an open window so that in about two hours the oil had evaporated, leaving a slight glossiness and a faint kerosene odor. The odor disappeared, but the glossiness remained next morning.

On the 29th no crawling larvæ were seen, and the fruit was examined daily until September 3d, no young showing at any time. The fruit had been a little bruised when brought in, and decay had started at this point September 3d, but otherwise it was entirely sound.

September 8th the surface was a little wilted, but no more than in some other specimens brought in as checks at the same time. The decaying spot had become larger, but there was no abnormal appearance in other respects. The fruit was cut to facilitate examination, and after two hours' work, during which every scale was turned, not a living specimen was found even in the most sheltered part of the calyx. There was no appearance of injury to the flesh of the pear and no abnormal flavor—in fact the absence of flavor was the noticeable feature and probably due to the kerosene.

On the check fruits brought in at the same time were crawling larvæ and scales of all ages, as well as adult males and specimens of *Aphelinus fuscipennis* Howard.

Nearly another two hours was spent in examining a large fruit of Japanese quince, taken from a plant sprayed with kerosene August 27th, at Parry, and sent me September 1st. The result was as before, not a living scale insect was to be found.

As to the killing power of the kerosene there seems to be no possible doubt after this experiment, which demonstrates also the penetrating action of the oil, which is its main advantage over the soap mixtures.

At Parry, kerosene was used on bearing trees as supplementary to the whale-oil soap.

June 18th on none of the kerosene-treated trees could any living scale be detected in any stage. Untreated trees were swarming with larvæ.

July 14th a few young scales were discovered, showing that probably a few examples had survived. The difference between the kerosene and fish-oil trees was very obvious at this time, and all in favor of the kerosene.

August 27th Mr. Bartram informed me that scales were still very scarce on the trees treated with kerosene, and that it was hard to find any of this season's growth.

September 25th most of the fruit had been removed, and it was said that a little sprinkling of scale was found on the pears through-

out the treated orchard. At this date a few living scales could be found by careful search on almost any tree.

Early in July purple beech and *Rosa rugosa* infested with scale were sprayed with undiluted kerosene, and on July 14th Mr. Bartram and myself looked over the beech plants rather carefully without finding a live insect. Some examination was also made of the sprayed rose shoots, and no living scales were discovered; but this was unpleasant, to say the least, and the search among the thorns was soon abandoned. It may be said that these plants seemed to remain free up to the last days of September.

About this date a Duchesse pear tree was sprayed with undiluted kerosene, and Mr. Bartram reported that in September a few live scales were discovered on it. I did not see this experiment, but have no doubt Mr. Bartram's report is correct.

It remains to note one case on the other side. August 14th Mr. Horace Roberts sprayed six pear, plum, peach and cherry, and some apple trees, with undiluted kerosene.

September 25th there was nothing to distinguish them from their untreated neighbors. All were swarming with scales in all stages and yellow with crawling larvæ. There was nothing to indicate that even a single individual had been killed, and the application must be considered a complete failure. I confess that I am quite unable to understand it, and if I did not have entire faith in Mr. Roberts' truthfulness I would not believe that the application had been actually made. This is the only break in the otherwise uniform record, and is given to suggest the possible existence of some factor not yet understood.

September 1st the following circular letter was sent to the newspapers of the State, to the leading agricultural papers, to the Entomologists of the various Stations, and to such individuals as I had some reason to believe had scale-infested trees:

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS.

TREATMENT FOR THE SAN JOSE SCALE.

Though the 1897 experiments with insecticides against the San José scale are not yet completed, the results so far obtained indicate the desirability of a change in the treatment heretofore recommended. Instead of winter applications, summer work will, it is believed, prove most satisfactory, and kerosene, undiluted, most effective.

The details of the experiments must be reserved until the work is completed, but that the balance of the season may not be lost to those who have scale-infested trees or plants, the following recommendation is made:

Spray thoroughly in September all infested, bearing apple, pear, plum and peach trees with undiluted kerosene during the middle of a clear, sunshiny day.

Treating nursery stock or very young trees with undiluted kerosene is not now recommended, since it is not yet certain that serious injury may not be caused.

The scales will continue active throughout September, and kerosene has proved uniformly fatal to all stages in all experiments made thus far. No injury has been caused on any treated trees except on plum after a spraying made in early spring, and this injury was temporary. In addition to the plants above named, Purple beech, *Rosa rugosa* and two species of *Spiræa* have been sprayed with undiluted kerosene without resulting injury.

By "undiluted kerosene" is meant the ordinary burning fluid used in lamps, in exactly the condition in which it is purchased. It should be applied in the finest possible spray, and every part of the plant should be thoroughly wet, but no more. One application should be sufficient, and it may be delayed, if necessary, until the fruit has been removed. The earlier the application is now made, however, the better it will be.

JOHN B. SMITH,
Entomologist.

New Brunswick, New Jersey, September 1st, 1897.

As a result, a number of applications were made, of which I received reports.

In September, Professor G. Harold Powell, of the Delaware Station, treated plum, peach, apple and pear, and on October 5th he wrote: "They still retain their foliage as well as the unsprayed trees, and the scales, so far as I can find, are absolutely dead. On one peach tree that was yellow with young scale when sprayed, there is not a living young to be seen, nor have I yet found an old one alive."

October 15th I saw Professor Powell at Chestertown, Md., and was informed that the above report still held good. The application seems to have been completely effective and the trees seem entirely unharmed.

October 15th I also saw, at Chestertown, Md., Duchesse pear trees sprayed with undiluted kerosene by Professor W. G. Johnson, of the Maryland Station, early in the morning, at midday and in the evening. None had been injured so far as could be judged at that time, and Professor Johnson stated that he had not yet found a living scale in any stage.

October 19th Mr. Martin Burrell, of St. Catherines, Ontario, Canada, wrote: "You will also be interested to hear that I sprayed with pure kerosene a Japanese plum tree which was badly infested.

After an interval of five days the tree was uninjured, and as far as I could find all scales were dead."

A consideration of this record shows that trees treated in February showed no trace of live scales until September, and it is not certain that these were not new infestations. Trees treated during the summer were not harmed, while the scales were killed, re-infestation or imperfect effect being noticed in one case. Trees treated in September or early October showed no apparent injury late in October, while in no case were living scales observed after the application was made. The record is not only encouraging, it affords us the solution of the scale problem when adapted to the needs of the different crops.

The latest record of the Ohio experiment is in a letter from Mr. Webster, dated October 25th, 1897, he says: * * * "We have seen the trees at New Richmond twice since the first of May. When I saw them May 17th I found an occasional scale on a very few of the trees, and some of them seemed to be entirely free. My assistant went over the orchard about two weeks ago, and while he found no indication of injury from the kerosene treatment, he did not find a single tree that was entirely free of scale, but, unfortunately, he did not go over the same trees that I did in May. As not all of the trees were treated with kerosene there is, of course, a possibility of these having spread from the untreated trees during the summer. I have about concluded that, with one tree to begin with, the ants can scatter them over an entire orchard. However, I do not believe that one spraying with kerosene is sufficient."

In Bulletin No. 81 of the Ohio Station, above referred to, the trees at New Richmond were found in good condition May 17th, two exceptions being noted of trees previously much hurt by the scale. Later it was found that one of these trees was also completely girdled by borers, and would probably have died anyhow.

The results of the experiments recorded in the bulletin are quite contradictory, but indicate that care must be used in making applications to peach trees. Mr. Webster remarks October 26th: "Our experiments with kerosene, and the results of applications to the same kind of trees in different parts of the State have been so conflicting that I do not feel as if we had learned much in the past year."

Fig. 13.

Fumigating Pear Trees in Maryland. Covering Tree with a 30-foot Sheet Tent. (From a Photograph made by Prof. Powell.)

Fig. 12.

Fumigating Pear Trees in Maryland. Lifting the Tent After Treatment.
(From a Photograph made by Prof. Powell.)

Fumigation.

Fumigation in this connection means exposing an infested plant, shrub, or tree to the effect of a poisonous gas produced by the action of dilute sulphuric acid upon fused cyanide of potassium. This forms hydrocyanic acid gas, and is intensely poisonous to animal and plant life. It acts rapidly in most cases, but organisms differ greatly in their susceptibility. Plant life is not so readily affected as insect life, and this makes it possible to employ the gas as an insecticide.

The proportions usually recommended are: One part by weight of fused cyanide, ninety-eight per cent. pure, one part by measure of commercial sulphuric acid, three parts by measure of water. The water is placed in a glazed earthen vessel, the sulphuric acid is added, and when the receptacle is in place the cyanide of potassium is dropped in.

To make this fumigation effective the plants to be treated must be inclosed by a practically gas-tight covering, and must be submitted to the action of the gas for from twenty-five to sixty minutes, depending on circumstances.

Fumigation was developed on the Pacific coast for the destruction of the cottony cushion scale some years ago. It is now used there quite generally for scales on *Citrus* trees, but is rarely employed against the San José scale except on nursery stock. A brief reference to this method of treating the San José scale will be found in my report for 1896, and the matter would not have been again referred to but for the fact that Professor Johnson, of Maryland, has advised its use in that State as the most promising method of securing extermination.

My experience with this method is slight and at second hand, but so far as it goes is not favorable.

An apparatus for fumigating was constructed according to my directions for the treatment of nursery stock, and was, in effect, a very large box of oiled duck. The frame was of scantling with the canvas lapped and closely nailed on three sides and top, one side being made to fold back to admit the stock. The fold was closed between two uprights, making a gas-tight joint; at the bottom earth was hilled against the edges so as to make a good closure. The stock was piled on a coarse slatting to keep it from the ground, and all treatments

were with the largest amounts recommended and for the longest times. In no case did a single fumigation kill all the scales. In some cases live scales occurred after a second fumigation, and only after a third fumigation did all scales appear to be dead. All examinations were made from eight to ten days after treatment, and it is possible that the gas was not given a fair chance since, as I am informed its effects appear very slowly, and an insect that seems at first apparently uninjured may die later.

I had occasion also to test the accuracy of reports of successful fumigation in another State, and have learned that live scale now exists on stock that was supposed to have been thoroughly cleared.

Professor Johnson has had better results, however, and fumigated stock in 1896 on which no trace of live scale was found in 1897. There is no doubt of the correctness of Professor Johnson's observations, and they prove definitely that stock can be fumigated so as to kill every scale on a given plant. But whale-oil soap will do the same under favorable conditions. The real question is whether, on a large scale, fumigation is sufficiently certain to make it advisable to recommend it.

By the courtesy of Captain R. S. Emory, of Chestertown, Maryland, I had an opportunity to see the work in progress, October 15th, in his pear orchard. Most of the trees were dwarf Duchesse, all the fruit being off at that time. There were nine tents in use, varying in cost from $12.50 for a box-tent large enough to cover a twelve-foot tree to $25 for a thirty-foot sheet-tent large enough to cover a tree eighteen to twenty feet in height by bending the flexible shoots. Where the wood was old and stiff fifteen feet was the tallest tree that could be treated. The sheet-tents were octagonal in shape, the largest fifteen feet to the center or thirty feet in diameter. The box-tents were oblong canvas boxes, without frame and one end wanting.

The method of handling the tents is illustrated in Figures 12, 13 and 14, the plates being from photographs made by Professor G. H. Powell, of the Delaware Station, who kindly allowed me to use them. A crew of four men is needed, three of them to actually lift and place the tents in position, a fourth to attend to the chemicals. For tents of this size no machinery is needed, but the thirty-foot tent taxes the force employed, and yet covers only comparatively small trees. For standards of any age a derrick or other machine would be needed.

Fig. 15.

The Fumigating Box at Parry. Duplicates are in use at two other nurseries (From a Photograph.)

Fig. 14.

Fumigating Pear Trees in Maryland. The Tents in Place.
(From a Photograph made by Prof. Powell.)

Half an hour is required to complete the fumigation and nine or ten of the smaller tents can be handled in that time, making two hundred trees for a ten-hour day of steady work.

The cost of material is slight, ranging trom two cents to eight cents per tree for the chemicals. Over two thousand trees will be treated, and the experiment will be watched with much interest. The time selected is the best possible, for reasons which appear later, and if the gas can accomplish actual extermination it will certainly do it in Professor Johnson's hands. The results will conclusively determine the possibility of practically using the gas treatment in the East.

Meanwhile, the gas treatment of nursery stock offers the best chance of success at present, provided the work is carefully done. Where large quantities of stock are to be treated, a shed or large box should be built of narrow matched stuff, tight at the bottom and with any convenient arrangement for packing, unpacking and ventilating. Tightness is essential, and the boards should be put together with white-lead, while all doors or windows should close against felting and should be clamped into place. The cubic contents of such a box or shed can be accurately known, and the cyanide can be weighed out in exact parcels. There should be a frame or slatwork to keep the stock from the floor, and beneath which the gas should be generated. A long drawer can be arranged to open outside at the bottom of the box or shed, and in this the vessel containing the chemicals can be placed, so that when the drawer is in, the outer opening will be closed, while the vessel from which the gas is generated will be in the middle of the mass.

It is an advantage to have the necessary amount of cyanide in small pieces in paper bags, in which it can be placed in the dilute acid. The paper is readily eaten by the acid, but gives a chance to close the opening before gas is formed, and it prevents the sputtering which occurs when considerable quantities are used. The time for nursery stock can be increased to one hour, and the amount to one ounce cyanide for one hundred cubic feet of space.

The formula would be—for each one hundred cubic feet of space use:

Fused cyanide of potassium 98 per cent. pure	1 oz. weight.
Sulphuric acid—commercial	1 oz. measure.
Water	3 oz. measure.

Use a glazed earthenware vessel to generate the gas, and put in first the water, then add the acid, and finally, when all else is ready, drop in the cyanide.

The purity of the cyanide must be insisted upon, and in purchasing this point should be carefully kept in mind. In Maryland they pay 29 cents per pound, in 50-pound lots, f. o. b. in Baltimore. In California they pay 31 cents at San Francisco.

The amount of sulphuric acid is not so important; it may be added to the water until the mixture boils or sputters. It is better to have a slight excess rather than an insufficient quantity.

It should be kept constantly in mind that the materials used are powerful poisons and corrosives; that the gas combines the bad features of the bases, and that the residue is also corrosive and poisonous. It should not be put close to any tree or other plant which it is not intended to kill.

Fungous Diseases.

The existence of fungous diseases of the San Joeé scale was referred to in my report for 1896, and it was stated that the subject would be further investigated during the season of 1897. In my address before the State Board of Agriculture in January of this year I was able to announce that the indicated experiments were already under way.

At that time I had received from Prof. P. H. Rolfs, of the Florida Experiment Station, twigs and branches of live oak infested by a native scale allied to *perniciosus*, most of which showed the peculiar orange fruiting spores of the fungus which is scientifically known as *Sphærostilbe cocophila* Tul.

This material was divided into two parts, one carefully placed in my cellar so as to have a uniformly moderate temperature, the other again divided and one lot sent to Mr. Howard G. Taylor at Riverton, the other to the Messrs. Parry. These specimens were to be tied to infested trees in the orchard as soon as received, and that was done. I intended to duplicate the specimens in March or April from my reserve supply, but a thievish servant annexed it among other trifles, in the evident belief that it must be of especial value from my care in placing it, and I did not discover my loss until it was time to make use of the material.

Fig. 16.

Sphærostilbe coccophila Tul. on *Aspidiotus perniciosus* Comst., from an Artificial Inoculation on a Peach Tree—Slightly Enlarged. (From Bulletion 41 of the Florida Station.)

Fig. 17.

Cultures of *Sphærostilbe coccophila* on Bread. A portion of this culture was used to induce the infection photographed for Fig. 16—Natural Size. (From Bulletin 41 of the Florida Station.)

The twigs received by Mr. Taylor were tied to the branches of two badly-infested trees in January, and these were not treated in any other way during the winter.

June 12th I found the trees with the fungus-covered twigs swarming with young larvæ and some parts white with newly-set scales. Though the trees were a menace to the snrroundings they were left so that the fungus should have at least two months to show itself. No appearance of spread was observed from the infested twigs though the orange processes looked fresh and plump. Professor S. A. Forbes had sent me some cultural material a day or two previously and some of this broken up in water was applied to one branch of one of the trees, in the hope that a more rapid and effective start might be obtained for the disease.

June 16th Mr. Taylor wrote: "Can see a few young scales on a good many trees to-day, but they are fairly swarming on the two trees untreated having the Florida fungus tied on. I never saw so many at one time."

June 23d the trees were again examined and no trace of disease was noted.

July 15th matters were much as before, so far as the disease was concerned, but the trees were now so covered with scales that I considered them in danger and also a serious menace to the surroundings. It is more than probable that some of the scales that were now found on near-by trees had come from these two examples which had been swarming with larvæ since the beginning of June. Under the circumstances it was decided to abandon this experiment, and the trees were sprayed with kerosene as previously recorded.

Diseased twigs were sent to the Messrs. Parry in January, and on June 4th I sent them also some of the culture material received from Professor Forbes with directions for use.

June 10th they wrote that the application had been made, and on the 18th of that month I visited the orchard. The branches of live oak had been tied to three infested trees, and on all of these I found living scales in abundance in all stages. Several trees had been painted with the fungus culture.

July 14th found that the fungus on the old scales looked as bright as ever, but there is no sign of any disease on the pernicious scales. There is nothing to indicate that the fungus has taken hold of any

of them. The same story was obtained from the trees that had been inoculated with the culture material.

August 27th the fungous disease was found established on one tree that was inoculated with culture material June 10th. Mr. Bartram had noticed the orange processes a few days previously, hence between sixty and seventy days had been required to bring the disease to this stage. It appears in patches from low down on the trunk to the end of the old wood present when the tree was sprayed. The scales seem to be pretty well killed off and nothing was moving. None of the other treated trees showed any signs of the disease. The tree on which the "take" occurs is in the chicken yard and somewhat sheltered by a larger tree and by a fence. Possibly this may have had something to do with the difference in results, for all the other treated trees received the application at the same time and in the same manner. The treatment was made late in the afternoon by Mr. Bartram, and the weather was more or less damp at the time.

Up to September 25th no trace of the fungus was found on any other of the treated trees.

During August, 1896, Professor P. H. Rolfs sent me from Lake City, Florida, some cultures of the *Sphærostilbe* which I diluted and applied with an atomizer on two trees in the Lippincott orchard, on a hot, sultry day, when, though there was no rain and had been none for some time, the air was laden with moisture and the loss by perspiration was so heavy that the process of replacing it by imbibing liquid refreshment became a positive luxury. These trees were kept under observation but no signs of disease were ever observed.

The Entomological Department of the Station has no apparatus for making cultures of insect diseases, and without assistance such work could not be carried in addition to what is now required; hence it became necessary for me to secure material from other sources. The very great kindness of Prof. S. A. Forbes, State Entomologist of Illinois, who is fitted out for this kind of work and has the necessary assistants, helped me over the difficulty.

April 3d Prof. Forbes wrote:

"We have twenty-one test-tube cultures—some on peptonized gelatine and others on potato—which are in excellent condition, all pure growths and beginning to fruit. As soon as the spores are

Fig. 18.

San José Scale Attacked by the Fungus *Sphærostilbe coccophila*. The pale circles around the scales are the orange fruiting processes, and in some cases the scales have dropped off, leaving round or oval pale spots. (From a Photograph, and about Four Times Natural Size.

mature on these cultures we shall extend them into larger dishes, and thus get material for application in the field.

"The primary difficulty was to get pure growths from the dead coccids. This could only be done, of course, by the use of separation cultures in the beginning and the transfer of colonies of *Sphærostilbe* to our tubes. It is now twenty-one days since these tubes were inoculated, and it will doubtless be as long a time before we can expect ripe material for use out of doors."

May 31st the following was written: "I send you by American Express a little package containing some dried-up material, the product of two fruit jar cultures of *Sphærostilbe*. These are the first cultures from dead *Aspidiotus obscurus* sent me by Rolfs. The fungus is a peculiar one, not forming a powdery mass in fruit, as does *Sporotrichum*, but a gelatinous material which dries out, as you will see, to a very hard crust. I have had no opportunity to experiment with it, but think that you can perhaps make application of it best by moistening and pulverizing it in water and then spraying or sprinkling the solution upon the insects. As the fungus grew on corn meal, an ordinary nozzle would not distribute it well, since the particles of meal would clog the nozzle. I have six other fruit jars with a fruiting growth, two of which I will send you presently."

When received part of the material was sent to Mr. J. J. Albertson, Magnolia, N. J., part to the Messrs. Parry, as already recorded, and the bulk was prepared for application by myself.

The suggestions made by Prof. Forbes were closely followed, and on June 12th the application was made in the Lippincott orchard, near Riverton. Seven badly-infested trees were selected and the solution was poured on the trunk and branches and rubbed over the surface with the hand, so as to break up all lumpy material and bring it into actual contact with the scales everywhere. Tags were put on all the treated trees for identification.

June 29th Prof. Forbes wrote: "I send you another lot of the cultivated *Sphærostilbe* in the same condition as that previously sent you."

This reached me July 1st, and was carefully prepared and applied July 3d. This time it was sprayed with an atomizer on fifteen trees in the Lippincott orchard. The atomizer used is sold as the "Lightning Insect Exterminator," and proved well adapted for this

purpose. The trees were mostly Duchesse dwarfs, and no pretence to cover completely was made. The large branches and the badly-infested fruit were chiefly aimed at, and no spraying was done above the face line, for convenience of examination later on. All the trees were marked, and a few of them duplicated those first sprayed with the culture June 12th. All the trees treated June 12th were carefully examined, but no trace of diseased scales was observed.

July 22d examined all the treated trees, and, while I found no trace of fruiting fungus, I did notice quite a number of apparently unhealthy scales, *i. e.*, they seemed abnormally swollen and uplifted, while many were almost yellow in color throughout. There seemed also quite an abnormal scarcity of young scales.

July 29th made another examination after a week of almost continuous rain. On the treated trees, matters were in apparently the same condition as before. There were many dead scales, from full-grown down to half-grown examples, but no trace was visible of fruiting fungus.

August 7th another inspection developed nothing new. The weather was somewhat more settled, and young scales and active larvæ were more plentiful than before. No apparent differences between treated and untreated trees were now noted.

August 27th the trees were submitted to another close examination. On this date the fruiting fungus was found at Parry; hence the search here was quite thorough. Unfortunately it was quite unsuccessful. Larvæ and young scales were now very abundant and the fruit was becoming covered.

September 15th and September 25th the trees were again seen, and on the former date were carefully examined. No trace of the fungus was discovered, while the scales were much more active than at any time before during the season.

October 23d no trace of fungus was found when I submitted the whole orchard to another careful examination. It is fair to note this experiment a failure.

It should be said that both my applications were made about the middle of a dry, sunny day, and under conditions that are now known to be unfavorable. I was not aware when the cultures were applied that a moist condition, continued for some time, was necessary to secure germination.

Part of the first culture received from Professor Forbes was sent to Mr. J. J. Albertson, Magnolia, N. J., and he wrote August 13th: "From some unknown cause all the San José scale have disappeared from the infested trees in my garden."

August 19th I was at Magnolia, looking over the condition of affairs in that garden, and found it a perfect jungle of fruit trees, vines and small fruits. The trees touch, and everything favors the development of the scale, which in times past has killed off several trees. All sorts of treatments have been employed, but nothing very radical or thorough has been attempted. Here several colonies of the Californian lady-birds were liberated last year, and I kept a close lookout for traces of these insects, but found none. At this time it was almost impossible to find living scales on the trunks or larger branches. Even the fruit is fair and only a few examples were found that showed even a trace of scale. I could find a number of spots on fruit which had evidently been caused by scales, but the insects were gone. Active larvæ were scarce and visible only near the tips of the twigs. A number of breeding scales were found, but the larvæ were not active. Many larvæ had set, had become covered with the first scale and then died. A much greater number had reached the first moult, but had never gotten beyond that. In several cases I examined all the scales on a twig or fruit, and found only dead insects. Some factor evidently decreased the vitality of the scales and carried them off in large quantities. Yet there was little appearance of abnormality and none of fungus. The insect beneath the scale was flat and dry, without appearance of spores, fungus threads or similar material. There was no appearance of any enemy either external or internal.

The fungus culture had been applied to an akebia vine on one of the porch pillars, and here the scales were perfectly normal in all respects, while larvæ and young were present in abundance. This vine has been badly infested four years, and seemed to be quite as vigorous and healthy as its uninfested neighbors. It is also interesting that the scale has not spread from the vine on this post to that on the one next to it. Whatever the cause of the mortality among the scales in the garden, the *Sphærostilbe* had nothing to do with it.

September 25th Mr. Albertson wrote: "I examined with magnifying glass the scales on my vine at the corner of the porch this morn-

ing. I treated this with the fungus culture. The scales are healthy and show no disease whatever. Many of the pears on my Garber trees are spotted—show much plainer than when you were here." This must also be chronicled as a failure.

After I discovered the loss of my infested twigs early in the spring, I applied to Professor Rolfs for an additional supply, and on June 9th he wrote: "By yesterday's express I sent you a box of the San José scale fungus.." Incidentally he notes that "of course it is entirely too early yet to say whether this fungus will be of any value outside of the moist Southern States." The box came duly to hand and was at once reshipped to Mr. Horace Roberts at Fellowship, who wrote June 15th: "The box of twigs received last evening and I will put them on my trees the first thing this morning."

July 7th I examined the trees and found no very obvious results The material on the branches looked good and in some places it appeared as if the young scales were affected, *i. e.*, many of them seemed to be abnormally uplifted.

The orchard was revisited September 25th, and on that day the fungus was found on almost if not quite all the trees on which twigs had been tied. It had usually spread pretty well over the tree and in some cases was obvious from the surface of the ground to the extremities of the branches, hundreds of patches of the orange fruiting processes being everywhere noticeable. I did not find any cases where the disease had spread from the tree on which it was originally introduced; but it may have been present in another, less visible stage. By no means all the scales on the trees containing the disease were dead. Indeed, there was an abundance of living material in all stages for the fungus to thrive upon.

This experiment may be counted a success, in so far as the disease has been actually established among the scales on a large number of trees in an orchard under perfectly natural conditions.

I notified Professor Rolfs of the success attending this experiment, and in reply to certain questions he wrote, October 1st: "Yes, the fungus will continue to spread for a considerable time this year; just how long will be determined by the temperature. It germinated and grew in my laboratory at 19° C. [66° F.] I do not know the minimum temperature for its growth, but it grew all last winter, and the thermometer went below 0° C. [32° F.] several times. It has been

reported as a native to Pennsylvania, so I think it will stand New Jersey winter all right. Whatever may be the result of experiments in Northern States, I feel sure that it is and will continue to be an important factor in controlling the San José scale in the Gulf and South Atlantic region."

It may be added that the disease has been found native in Maryland, and since Professor Rolfs records it also from Pennsylvania, it is fair to assume that in our southern counties it will survive ordinary winters in the fruiting spore stage. I am quite hopeful of good results from this fungus, but our experience with similar diseases against other insects does not give us any just reason to expect that it will do more than check the scale. In favorable seasons it may reduce the insects to very small numbers, but with their wonderful powers of reproduction a year or two will bring them up to their former point. The worst feature is that moist conditions are required for the best development of the fungus, while it is in a *dry* time that the scale is most active. Wet weather, especially if at all cold, is in itself a check to the scale, while in dry, warm weather it increases enormously. Nevertheless it is desirable to have this disease established in New Jersey, and the following account is taken from Bulletin No. 41 of the Florida Station, by Professor P. H. Rolfs, to whose courtesy I owe the opportunity of reproducing Plate Figures 16, 17 and 19.

The general remarks preceding the "Biology" in the bulletin are given in extract only, since they refer in some cases to the experiments detailed in the bulletin.

1. The best time to apply the culture material is after sundown on a moist evening; but this condition may be produced artificially by wrapping an inoculated trunk or branch with a wet cloth.

2. The spores raised on bread germinate in a few hours and must find a suitable medium in which they may grow (*e. g.*, San José scale) or they will perish.

3. The spores produced in the orange-colored protuberances (Figure 16) seen on scales live for several months in dry weather.

4. The material can be produced in great quantities, and its application to the insects is as easily accomplished as a single spraying with an insectide.

5. It is more thorough than insectides.

6. While it is "nature's own" remedy for striking a balance in Florida, it will doubtless be less effective in dryer climates.

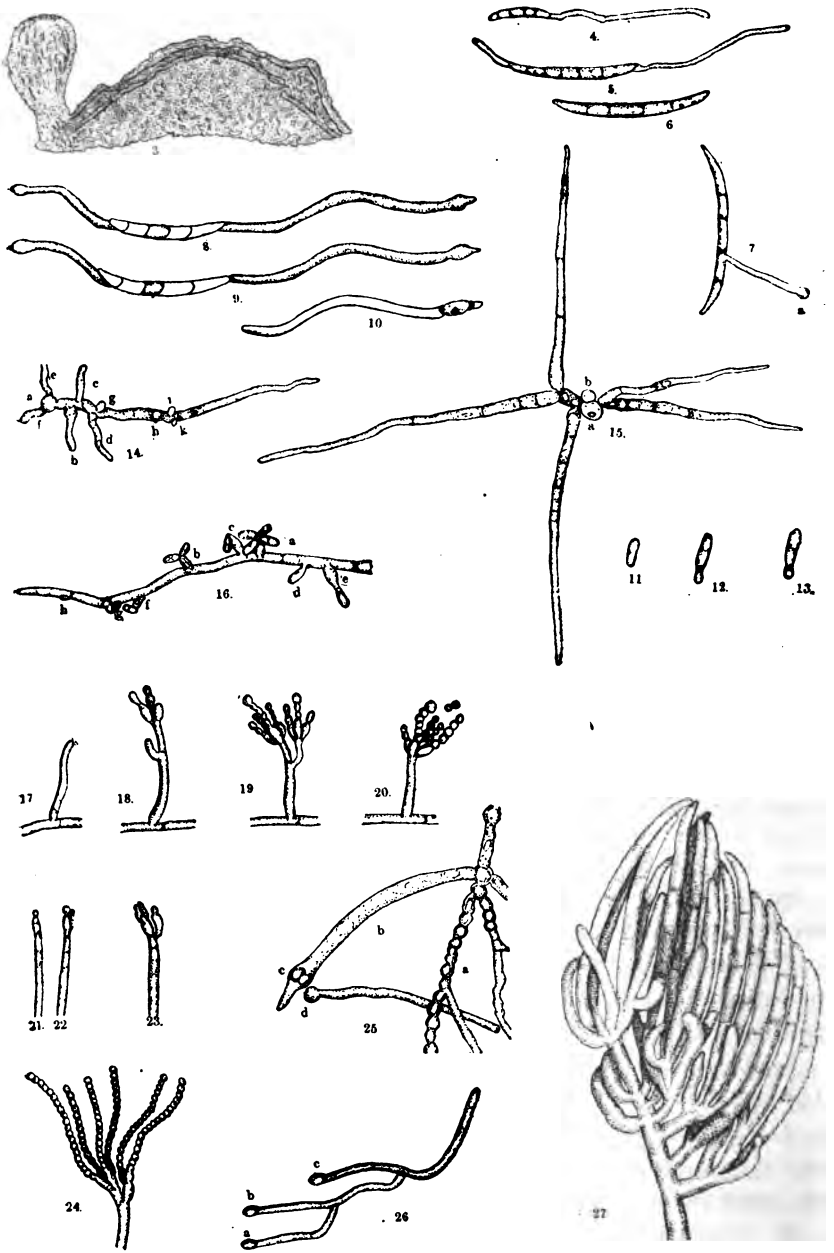

Fig. 19.

7. The fact that this fungus is widely disseminated on a native scale insures a constant supply of new material, thus avoiding the necessity of using any that may have become attenuated.

8. The fungus multiplies many times more rapidly than the San Joœé scale.

9. As soon as the insects have been killed rains wash the fungus and dead scales from the trees, leaving no signs that they have been diseased except where the insects have injured them.

Biology.

"A San Joœé scale attacked by this fungus is usually transformed into a mass of mycelium before there is any exterior appearance of a change. When the body of the insect has been consumed a bright orange-colored protuberance forms at the base of the scale, or at times it breaks through the protecting cover of the insect. This orange-colored protuberance is the most conspicuous part of the fungus and the only portion visible to the unaided eye. These vary in size from an eighth to a fortieth of an inch.

"These that measure about a sixteenth of an inch are the most abundant under favorable conditions. Figure [19] *3* represents a cross-section of a scale insect and the spore-bearing protuberance magnified twenty-five diameters. The outlines of this figure were drawn by the use of a camera lucida. These spore-bearing bodies may be seen in Figure [19] *16* as small projections enlarged less than two

EXPLANATION OF FIGURE 19.

*3, cross-section *Sphærostilbe* stroma and San José scale. *4, Small conidium spore germinating. 5, Larger conidium spore germinating. 6, A large conidium spore. 7, A conidium spore germinating from a cell; a, Sporidium. 8, Large conidium spore germinating from both ends: the middle cell has not discharged its contents. 9, Further development of No. 8. 10, Sporidium completed. 11, Spore taken from figure 16 and placed in distilled water. 12, Development of 11. 13, Development of 11 completed and spore-like body produced. 14, Sporidium placed in slightly nutrient media; a, sporidium, b, first branch of the mycelium, c, second branch of the mycelium, d, third branch of the mycelium, e, mycelium from sporidium, f, mycelium from sporidium, g, h, i and k, spore-like bodies. 15, Sporidium in medium containing more nutriment; a, sporidium, b, spore-like body. 16, Sporidium germinated in standard nutrient media; a, b, c, d, e, f, and g, Sterigmata. 17, Hypha grown in liquid media. 18, Hypha further advanced. 19, Hypha still further advanced. 20, Hypha with mature spores. 21, Hypha grown in solid media. 22, Hypha still further advanced. 24, Hypha bearing mature spores. 25, Growth in media, a, necklace form of mycelium, b, enlarged mycelium, c, spore-like body, d, spore-like body germinated. 26, Spores with anastosmosing mycelium, a, b, and c, original spores. *27, Conidia spores attached to branching basidia.

*3 enlarged 25 diameters. 4 to 14 and 16 to 26 inclusive, enlarged 180 diameters. 15 and 27, 240 diameters.

diameters. These small projections contain a great many spores, represented by Figure [19] *6*, enlarged one hundred and twenty diameters. These spores, under favorable circumstances, mature within six weeks from the time of infection. Countless numbers are liberated from the orange-colored protuberances during rains and are washed down the trees and some to the ground.

"If a moist atmosphere continues for several hours these spores will germinate and produce sporidia, represented by Figure [19] *7*, *a*, which at maturity may be carried about in the atmosphere. In case the spore represented by Figure [19] *6* finds lodgment in a place suitable for further growth, a sporidium, represented by Figure [19] *10*, is produced. Under favorable conditions sporidia germinate in the course of three or four hours, otherwise they retain their vitality for only a few days.

"These sporidia, represented by Figure [19] *7*, *a*, on germinating in a situation where there is only a slight amount of nutriment for this fungus, produced a growth represented by Figure [19] *14*. Figure [19] *14*, *a*, represents the original sporidium which germinated and produced the larger mycelium, after which the branches *b*, *c*, *d*, *e* and *f* were successively produced. Consecutively with *e* and *f*, *g* and *h* were produced; then followed *i* and *k*. While *g*, *h*, *i* and *k* are morphologically aborted branches of the mycelium, they finally become inclosed in a wall and later are detached to perform functions similar to those of a sporidium. The production of the spore-like bodies *g*, *h*, *i* and *k* marks a cessation of vegetative activity. These spore-like bodies *g*, *h*, *i* and *k* have the power to germinate even in distilled water, but produce a mycelium that is not more than two or three times the length of the diameter of the spore-like bodies. If, however, the medium in which it is grown contains a sufficient amount of nutriment, vegetation goes on freely, and a fungus plant may result, as in case of germination of a sporidium.

"If a sporidium be placed in a slightly stronger nutriment solution, growth represented by Figure [19] *15* takes place. In Figure [19] *15*, *a* represents the secondary spore, and *b* a spore-like body produced after considerable growth of the mycelium had taken place. This spore-like body may be formed directly from the secondary spore or from the mycelium, and may be liberated before other spore-like bodies are produced, or before the mycelium has ceased to grow. In other respects the body represented by Figure [19] *15*, *a*, is similar to Figure [19] *14*, *g*.

"If a sporidium is transferred to a strong liquid nutrient medium, germination takes place in a few hours and a much stronger mycelium is produced. Finally, by the production of spores and continued vegetation a dense felty mass is produced. Figure [19] *16* represents a branch of the mycelium-producing spores. Under these conditions spores are borne on sterigmata, *a*, *b*, *c*, *d*, *e*, *f* and *g*, which were produced in succession as lettered. At *h* is represented the beginning of a sterigma. These spores are produced one at a time, and when fully formed may be detached by a slight jar, but if handled carefully they may remain attached loosely until as high as four have been formed, when the formation of a fifth will detach one or more of the older ones. Some sterigmata produce more spores than others that seem to have equal advantages; some remain sterile. Figure [19] *16*, *d*. Spores produced in this way retain the power to germinate for nearly a month in a humid atmosphere, but lose it after remaining in a dry atmosphere for only a few hours.

"In connection with these spores a very interesting phenomenon occurs. The mycelium seems to have a power of inhibiting the growth of spores produced in this way. In cell cultures a great many spores collect near the mycelium, but do not germinate; when the same spores were removed only a fraction of an inch from the mycelium many of them germinated, and when they were removed to the other edge of the hanging drop the normal proportion germinated.

"The growth of such spores placed in distilled water is represented by Figures [19] *11*, *12* and *13*, in successive stages of development. Figure [19] *13* represents the original spore *11* enlarged into a rudimentary mycelium, which has divided into two cells and produced a spore-like body at lower end, which is similar to Figure *14*, *g*.

"At intervals on the mycelium such as represented by Figure [19] *16*, hyphæ are produced that protrude from the medium in which it is growing. The successive stages of these hyphæ are represented by Figures [19] *17*, *18*, *19* and *20*. The length of these to the spore-bearing portion varies with the depth of the medium in which it is growing. It is apparent from the beginning that such a branch as represented by Figure [19] *17* has some special function to perform. Gravity seems to have no influence upon the direction, but it seems to take the direction of least distance to atmosphere. By comparing it will be noticed that these hyphæ bear sterigmata similar to those in

Figure [19] *16*, which bear a number of sphærical spores; the first one formed, or the one at the distal end, is the largest. These spores are easily dislodged, and are much slower to germinate than the spores represented by Figure *16*.

"Figure [19] *25* represents a very interesting form taken by the mycelium at times. In the beginning the mycelium does not seem to differ from the ordinary forms, but in the course of four or five days this is changed into a necklace-like form, represented by Figure [19] *25*, *a*. A second portion of the mycelium, Figure [19] *25*, *b*, has become much enlarged. This enlarged portion (*25*, *c*) then produces spore-like bodies which germinate when they become detached. Figure [19] *25*, *d*. After these spore-like bodies become detached more of a similar character may be formed.

"Spores of this fungus were placed on agar gelatine, on live San Joeé scale and on live obscure scale (*A. obscurus*) in culture cells. In these cases the spores developed in quite a different way from all but those represented by Figure [19] *20*. Figure [19] *21* represents a young hypha. Figure [19] *22* shows a hypha further developed. Figure [19] *23* shows the sterigmata, also the beginning of sphærical spores. Figure [19] *24* represents a hypha at maturity. In a dry atmosphere these spores separate easily and may be carried about by the wind; in a moist atmosphere they cling together in chains. These spores have been kept for several days in a dry atmosphere without losing their vitality. If twigs containing scale insects attacked by this fungus be placed in a moist chamber this kind of spores is produced in such quantity that they become visible to the unaided eye, making the insect appear as if covered with a minute blue mould. Pure cultures may be obtained with greatest ease by using these spores.

"Such spores as are represented in Figure [19] *16* (with Figures [19] *11*, *12* and *13*) were sown in distilled water, where they germinated in a few hours. At the end of twenty-four hours the mycelium had grown to eight or ten times the length of a spore. After about forty-eight hours further growth ceased. A very peculiar phenomenon was noticed repeatedly. Spores under these conditions germinated in a short time and grew rapidly about twelve hours, then grew more and more slowly until their full growth was reached in about forty-eight hours. During the early portion of growth the mycelia took independent courses, but later the end of *26*, *a*, bent towards *26*, *b*, with which it united. In this case *26*, *b*, seemed to be benefited by the

union. This second mycelium then grew out to *26, c*, with which to unite, which in turn received support from *26, b*. As this occurred repeatedly it is difficult to resist the conclusion that there is some affinity between these different mycelia in distilled water. The mycelium of this fungus does not, as a rule, anastosmose in nutrient media."

To this account a very necessary addition must be made. As at present organized this department is in no condition to make the cultures required to secure a sufficient supply of the material for field use. There are no appliances for the purpose and there is no assistant. Both would be necessary and would require at least $2,000 to insure a thorough distribution of the disease to all scale-infested districts in the State.

Field Notes.

The life history of the insect is fully given in the report for 1896, as well as in the bulletins already issued from the Station, and these should be consulted in this connection.

No observations were made until June 12th, but on June 10th word was received from Parry that no young larvæ had yet been certainly identified. Five days later Mr. Bartram wrote: "We noticed to-day a considerable number of running larvæ of San José scale. None were noticed to have settled."

June 12th larvæ and recently-set scales were found on the check trees in the Taylor orchard, but none had passed the first moult. It is safe to say that none were produced previous to June 1st.

In the Lippincott orchard no young scales were observed, and no crawling larvæ. This is unusually late for the insects to make a start, and raises a question whether the spraying has not had a retarding effect, even if it did not kill. It seems almost as if only the youngest forms had survived the application, and that there could be no hatching until these had come to maturity. The unsprayed Taylor trees have at least a week the start.

June 18th, at Parry, found that there was not yet any general production of young. Even where live scales were plenty there were cases where no young have been hatched this year. Untreated trees were here nearly as backward as others.

July 3d there were young scales in abundance in the Lippincott orchard, and many larvæ, but none of the new scales had passed the

second moult, and none would be in condition to reproduce for some time. The larvæ emerging at this time seemed to be making for the fruit, and some crippling was promised. Matters seemed in just about as bad a shape as at this time last year, but the infested area was not appreciably extended.

It is quite noteworthy that the spread from this patch of very scaly trees has been extremely slow. The area has not been extended one hundred feet in the three years that the orchard has been under observation. The dwarf Duchesse bear the bulk of the infestation, and even in the same rows with them other varieties may be practically exempt. A curious fact was emphasized this year; in an orchard of Keiffer trees, when it once becomes infested, the scales flourish as well as anywhere, and the trees become as completely incrusted as any other variety. But where Keiffer is mixed with other varieties it remains almost exempt, even when neighboring trees are badly infested. This was noticed several times, and Le Conte seems almost less troubled than Keiffer.

July 29th, after a week of almost continuous rain and low average temperature, scarcely an active larva was to be found anywhere in the Lippincott orchard. There were plenty of living scales, but there is no doubt that the continued wet weather has acted as a serious check to breeding. Looking over the baskets of fruit that had been gathered, it was noted that there is a scattering of the scale throughout the orchard in places where it cannot be found on accessible parts of the trees.

August 7th the same backwardness in breeding was noticed, and particularly on the older trees, with a large top, there is little reproduction going on. It seems almost as if the insects detested shade and could not thrive in it.

August 19th I visited the orchards of Mr. Horace Roberts, on Pensauken creek. Here scales were found in 1896, evidently introduced from a Parry orchard more than half a mile away on the other side of the creek. The trees were again examined to determine what spread had been made, but not a live scale could be discovered, though I found their marks, and Mr. Roberts assured me that my recollection as to the infested trees was correct. No insecticide applications of any kind had been made.

Another series of trees farther along the bank was examined, and on some of them an occasional full-grown scale was found. There

was always one only, usually alive, and there was not the slightest indication that it had been born anywhere near where I found it. In other words, this is a new infestation brought in this year, probably from the same source as that found last year. All the scales observed were females and, unless males are where I could not find them, they will die out. The interesting point is that the scale having gained a foothold and actually begun to breed, for specimens were seen on the fruit last year, has died out without any attempt made to subdue it.

August 27th, at Parry, found that even where no treatment was made the scale had not more than held its own. At the Lippincott orchard the scales were much more active than at any previous time, and this may be due to the fact that there has been no rain for several days. Fruit yet on the trees is rapidly becoming covered, but is of a size to prevent the crippling that was so noticeable last year. While, perhaps, more trees are badly infested than were so last year, the fruit is, on the whole, much better.

September 15th there was not much change. The weather was now as dry as it had been wet earlier, and the scale was breeding faster than at any other period during the summer.

September 25th most of the experiment orchards were visited with Professor Powell, of the Delaware Station. The scale was active everywhere, but, except at Fellowship, nothing new was observed. At Fellowship the fungous disease was found, as already recorded, and an almost unexampled activity among the scales.

The effect of the scale on peach was well illustrated here. Although some treatment has been applied every year, yet many of the trees have been so injured as to be useless. Even if they survive the winter they can hardly recover if rid of the scale completely. Last year a similar case was observed and the trees were taken out. Peach will not stand more than three years of San José scale and when once the infestation is so general that all the branches are covered the tree dies. In this case a distinct poisoning effect is noted in the wood which results in its death sooner or later. Any severe treatment will simply hasten death. An interesting instance was related to me by Professor Johnson: In a large orchard in Maryland a small center was infested by San José scale and the trees died the third year—cause unknown; next year a circle of trees surrounding this center died—cause also unknown; this year another ring of dead trees marks the further extension of the scale, now discovered as the cause of the injury, and

Professor Johnson has found that many others are so infested that they cannot survive next summer. Others are slightly infested and if left will stand another year. Badly-infested peach trees are better taken out for this reason, and there should be no hesitation in risking severe measures on those moderately infested, since it is simply a question of life or death in any case.

October 23d the scales were still breeding at Riverton, but slowly. The larvæ were few in number and not very active. It is probable that most of the scales now setting will hibernate and not likely that any new breeders will be developed. Those already reproducing will probably continue to do so until it becomes too cold. Quite a number of Keiffer trees were yet loaded with fruit and hardly a scale to be found on it.

Taken altogether the interesting features of the season were the late start, due to wet, cold weather, the slow breeding during the wet early summer and the rapid development in enormous numbers after the middle of August. Taking it as a whole, the scale has made little advance as compared with last year; but it must be noted that it has been introduced into a large orchard of old Keiffer trees nearest the Lippincott place. Probably birds carried the scale, and carried it from the infested spot across a road, a cultivated field and a rather young orchard into the far side of the old Keiffers. This spread was unknown until the fruit came in and the scales were seen in many of the baskets, indicating a general distribution.

The peculiar condition of the scales on the Albertson place, at Magnolia, requires explanation, and possibly the dense shade made by the closely-set trees may afford it. Evidently the scale does best in dry weather, and shade and moisture seem unfavorable. A somewhat similar case was noted near Beverly, where the scale was found early in September scattered throughout an old plum orchard, where the trees were very heavy and shaded the ground completely. All stages, from larvæ to adults, were represented here, but in a half-hearted manner, and most of the examined scales were dead. The infestation was not recent, because scales were found all over this place in 1895. At present a pear tree here and there shows a few scales on the fruit and, as stated, a few were discovered on the plums. No badly-infested trees from which larvæ might have been carried were discovered.

A curious case of persistence of the scale is reported by Mr. Kel-

sey, who relates that "in early spring I cut off my currant bushes at the surface of the ground, covering the stumps with several inches of soil and allowing the young currant shoots to make their way through it. In most instances the scale made its way up through the soil and took possession of them."

Nothing new as to natural enemies was learned. *Aphelinus fuscipennis* and *Pentilia misella* are actively at work in greatly-increased numbers, and on September 25th could be found in any quantity on the Roberts place. But they seem to make no obvious impression upon the prey. Nevertheless, these insects are increasing very steadily, and Prof. Johnson speaks of "thousands" of them on infested trees in Maryland.

Some more effective enemy must exist in the native home of the scale, if that is not our own country. Professor Cockerell's arguments that Japan is the true home of the species, have been already mentioned. He may be right, and if so, the scale problem must be studied there and perhaps its enemy can be found and introduced—not to exterminate, but to keep in bounds, its prey.

Conclusions.

The observations and experiments made in 1897 have been set down in detail to give a clear idea of what has been done and upon what the conclusions and suggestions here made are based.

The San José or pernicious scale is, in my opinion, permanently established in New Jersey. It must be accepted as an added hindrance to fruit culture to be systematically fought like any other of our native pests.

Accepting its continued presence here, every effort should be made to domesticate any known enemy of any kind; hence, the introduction of the *Sphærostilbe* should be systematically carried on until all places in which the scale is known to occur should also have the disease—this not with the hope of extermination, but of lessening the cost of control to the farmer.

The question of Japan as the real home of the scale should be investigated, but it will require $5,000 to do it.

This is *not* a repetition of the Californian experience, which offered little hope from the start; because California was not the native home of the scale; because the supposed enemies were Australian *Coccinellids;* because the climatic conditions were too contrasting, and

because there was not the slightest reliable evidence that the control of the scale was due in any way to the agents indicated.

It is not beyond the bounds of possibility that in time nature will come to our aid. Had this season continued wet throughout, the scale would have lost ground everywhere and would have gone into winter quarters in an enfeebled condition. A drought of six weeks' duration in late summer enabled it to recover lost ground, and it will go into hibernation about as strong as last year.

The scale can be controlled—not exterminated—by insecticide applications, but the applications are expensive and involve some risk to the trees or crop.

Fruits differ greatly in their ability to resist the scale and the treatment for it, and different varieties of the same fruit show differences equally great.

Keeping all these points in mind a course of practice is recommended, the explanation for which follows:

Remedial Measures.

1. Winter treatment should not be made until February, and may be delayed until March; it should be with either whale-oil soap, at the rate of two pounds in one gallon of water, or with kerosene undiluted.

If the trees are young, and have smooth bark, so that all the scales can be certainly reached, the whale-oil soap may be satisfactory. If the tree is older, or at all rough barked, use kerosene because of its greater penetrating power.

On peach trees the whale oil soap may be safer, but I would prefer to urge the kerosene at some risk, because of its greater effectiveness. In no case waste kerosene. *It needs only enough to wet* every part, and as the material is penetrating and spreads rapidly the finest nozzle should be used. It should go at least twice as far as an equal amount of whale-oil soapsuds.

2. Before the trees actually start growth, but *after* the spraying, they should be carefully and thoroughly pruned. All useless wood should be removed, and everything not actually necessary to enable the tree to make a good growth if not in bearing, or a moderate crop if bearing, should be taken out.

3. Watch closely all treated trees during the early days of June, say from the 1st to the 15th. If crawling larvæ are observed in even

the smallest number, spray that tree with either kerosene emulsion diluted five times, using whale-oil soap to make the emulsion; with the mechanical mixture of kerosene and water at the rate of five to one, or with whale-oil soapsuds one pound in one gallon. There will be some injury to the leaves, and in the latter case partial defoliation in some instances, but no harm to the tree nor to the fruit. *Use no more material than necessary in any case.* The "emulsion sprayer" described in a previous part of this report may be used.

4. Watch again about the beginning of September, and again treat any tree found yet infested as above directed.

5. As soon as the leaves are off search carefully for any trace of recently-set scales or larvæ, which may continue to be produced until the beginning of December, and again treat any trees yet found infested. This time, if kerosene is to be used, make it two parts of water to one of kerosene in the mechanical mixture. The emulsion will not stand less dilution without increased difficulty in application and a disproportionate increase in danger.

6. Assuming that the discovery of a bad infestation is made at any time before August, spray at once with pure kerosene, using the finest possible spray and no more than necessary to cover. The day should be dry and clear, and, if possible, with a breeze stirring. If the discovered infestation is slight, treatment can be postponed until the middle of September.

7. Assuming an infestation discovered after the beginning of August, let matters go until the middle of September or until the fruit is off, if in bearing, then use undiluted kerosene as already directed or whale-oil soap, one pound in one gallon of water. If the latter is used a second treatment should be made in February or March, using two pounds in one gallon of water. If the infestation is a bad one, a second kerosene treatment in February may be best, whether kerosene or soap was used in September.

Explanations.

It seems to have been proved that severe applications of soap in early winter injure the fruit buds of many varieties. Late applications are much less harmful, and some varieties, like the Keiffer pear, will stand almost anything. Apples are less likely to be affected than pears. Peach is liable to suffer at any time, but is also much the most susceptible to injury by the scale. For this tree freezing

weather should be selected for winter treatment with kerosene. It seems, however, that it stands summer kerosening at least equally well, if not better. As to plum, I have no satisfactory data. Cherry seems rarely infested with us. Quince is more tender than apple; but I do not consider quince trees in New Jersey worth treatment, so far as my observations extend. Badly-infested peach trees should be taken out at once, because they will not repay money or labor. Severe treatment added to the scale injury may kill or cripple them seriously, while ineffective treatment may possibly give one year's lease of life without sufficient probable return to pay for the expenditure of time and money. Vigorous trees, slightly infested, may be carefully treated with safety and with satisfactory results. Apple and pear trees, unless crippled, can be treated with a chance of good results, no matter how badly infested. Very young trees, if badly infested, are better taken out and replaced by clean, vigorous specimens.

If soap is to be used, it would be an advantage to apply in a dry time, especially if potash soap is employed. If a washing rain occurs within three days, the application should be renewed. With kerosene it is only important that it be dry and clear when applied and for a few hours afterward. It acts at once or not at all. The soap acts as long as any appreciable part of it remains on the tree. As to the effect on fruit buds, of kerosene, practically nothing is known. There was no injury where it was applied by Mr. Taylor or by Mr. Parry, and there is no theoretical reason to expect any on any variety. In Mr. Taylor's case Keiffers only were treated; on the Parry place Duchesse dwarfs and Howells.

I do not hesitate, under the circumstances, to advise even risky applications in badly-infested cases, for such trees would lose more to produce a scale-infested, low-grade and, perhaps, unsalable crop of fruit than would be lost to the grower if he had a good, healthy, uninfested tree at the end of the following summer. Nevertheless, if the crop of fruit is an object, the winter treatment may be entirely omitted, and in its place the application under 6 may be made early in June, as soon as the hatching of larvæ becomes general. This will save the fruit and will be sufficiently effective to check the scale so that it can be left until September, if, indeed, it does not eradicate it completely.

Under ordinary conditions no one treatment can be relied upon.

No winter treatment by itself has yet been successful on any large scale. That a single treatment may be completely effective under specially favorable conditions is certain, but it is equally certain that wherever even the most thorough treatment has been made on bearing trees in a commercial orchard a few examples have survived, though no trace of them might appear until September, as was seen in both the Taylor and Parry orchards. Some trees would probably be entirely cleared, but on the majority a few specimens would escape to begin breeding. Hence no one treatment, no matter how thorough, can be relied upon to be entirely effective, and winter treatment must be supplemented by close watchfulness and careful summer work. In fact, the summer work alone would be better than winter work alone.

It is really here that we have failed heretofore in our efforts to subdue the scale. We have relied upon winter work, and when that was found incomplete the scale has been left to itself during the entire season following. The result has been discouragement and a resort to legislation instead of to more persistent work.

The pruning is recommended because the most difficult scales to reach are those near the tips of the smaller shoots, especially if sheltered by or concealed under a bud. Any spraying may miss one or more of these tips, and the progeny of any scales from such localities would be extremely difficult to detect unless they got upon the fruit, which they would be very likely to do. The trimming would remove most of such danger spots, and on the larger branches and trunk the kerosene could be so thoroughly applied that it would be almost impossible for an individual to escape.

Very great stress is placed upon the careful examination of the trees in late September, and careful treatment at that time is as important as any other, for the following reasons: It seems fairly certain that none of the scales that begin breeding in one year live through the winter to resume work in spring; but they continue until actually stopped by frost. So far as I have observed, few scales begin breeding after the middle of October, and I have observed no males after that period. It is said that the very young scales do not pass the winter well; but on that point I have no personal observations to offer. It is fairly certain that the insects that pass the winter in the best condition are those that hatch in October and become not more than half grown. Any application made in early October will kill all the scales then breeding, all the crawling larvæ, and probably

all the recently-set scales, destroying thus the very forms that would be most likely to survive the winter, and those forms that might provide others for hibernation if they were left undisturbed. In fact, so important do I consider a treatment at this time that if I were confined to one annual application I would choose that one. The foliage is then mostly off, or at least mature, so as to come to no harm, the larvæ succumb to the kerosene at once, and the newly-set scales are readily penetrated. The breeding scales are uplifted to give exit to the larvæ and entrance to the kerosene, while in those that are not yet breeding, the edges of the scales are thin and growing; not nearly so close to the surface or so dense as in the winter. At this time undiluted kerosene is best. What effect it will have on the fruit buds is not yet certainly known; but I advise it even at the risk of losing next year's crop, if thereby the trees can be cleaned.

Finally.

Again let me repeat that I do not believe in the extermination of the scale in New Jersey. It has come to stay and must be dealt with. I believe also that it can be dealt with without particular difficulty, provided treatment is persisted in. When I say that in my opinion the scale cannot now be exterminated in New Jersey, it does not mean that it cannot be cleared out of an orchard by persistent work and kept out of it by care in selecting new stock. In a danger district where the scale can be carried in, individual trees must be treated as they become infested, to prevent spread from them. The outlook is by no means gloomy, provided we do not expect impossibilities. Sooner or later this scale will find its level, and as we become acquainted with it, it will lose its terrors and become easier to handle, which does not mean, on the other hand, that it is to be lightly regarded *now* or neglected, unless the sanguine individual is ready to pay the penalty.

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